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FRACTURES AND DISLOCATIONS

FRACTURES

AND

DISLOCATIONS

DIAGNOSIS AND TREATMENT

BY

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WITH A CHAPTER ON

RÖNTGENOLOGY

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TO
CHAS. B. LYMAN, M.D., F.A.C.S.
FROM WHOM THE AUTHOR RECEIVED
HIS FIRST INSTRUCTION
IN FRACTURES AND DISLOCATIONS

42730

FOREWORD

The object of this book has been to offer the reader a working knowledge of the subject in as few words as possible, avoiding for the most part all theories and arguments which are void of practical value for the surgeon who has to diagnose and treat the various injuries which are met with in actual practice. The author has endeavored to make the reader an eye witness to the various deformities as they appear immediately following the accident, rather than to offer him lengthy text in describing the lesions. There is much to be learned by inspection in the average case of fracture or dislocation, and the information thus gained may be put to immediate use with a minimum amount of manipulation of the parts and without being obliged to await the returns of an X-ray examination. The more one learns by inspection, in establishing a diagnosis in a given case, the less there remains to be determined by palpation, and if the surgeon develops the faculty of recognizing what he sees the patient will many times be relieved of much unnecessary manipulation and suffering to say nothing of the damage which may be inflicted on the already traumatized soft tissues. Photography, therefore, is the best means of recording the initial deformities, but the excitement, confusion and pain attending the average case of fracture are conditions anything but favorable for picture-taking. Moreover the varying conditions of light and the surroundings in which we find the patient, together with the necessity of having the photographic apparatus available and in good working order, are additional factors which work against the securing of such valuable clinical data and explain the scarcity of pictures of these deformities in medical literature. The illustrations of such deformities shown on the following pages have been taken under unfavorable circumstances, in a large proportion of cases, and (although the photographic appliances were the best obtainable including the fastest Goerz and Zeiss anastigmat lenses) the results, from a photographic standpoint, have been none too good in many instances. The pictures shown have been chosen from a large number of such photographs with the intention of familiarizing the reader with the average clinical deformity, rather than for the purpose of recording rare cases or those in which the pathology is obscure.

The time-honored, academic classification of fractures under one heading and dislocations under another has been abandoned, and the more practical method of considering the injuries according to the region in which they occur has been followed. Thus the reader will find all the injuries to which a given region is subject (including fractures, dislocations, joint fractures and fracture-dislocations) without looking up the different conditions in widely separated sections of the book or even consulting another volume.

The development of the Röntgen ray has been of inestimable value in the diagnosis of fractures and dislocations, and its use cannot be too highly commended; but, on the other hand, this very aid has resulted in our becoming more lax in other methods of diagnosis. The X-ray is a most valuable supplement to other physical clinical methods but it should not be expected to supplant them. The surgeon should make a practice of determining the nature and location of the fracture as accurately as possible (due care being exercised to avoid unnecessary manipulation) before the X-ray is taken, and later to compare his conception of the condition with the Röntgenogram. By making this a routine measure he will find that his diagnostic acumen will be materially increased as time goes on.

A certain mechanical sense is most essential in the treatment of fractures and dislocations, and no text-book can supply this to one naturally deficient in this respect. However, an attempt has been made in the following pages to supply the necessary data for the development of this sense and to place before the reader, as far as possible, some of the author's experiences.

The more common fractures have been accorded the greatest amount of attention since they are the conditions with which the average practitioner will have to deal most frequently.

Occasion is here taken to thank a number of members of the medical profession in Denver who have been of service in various ways in obtaining the material for and in the preparation of this work. Among others the author wishes particularly to express his gratitude to: Drs. C. B. Lyman, T. E. Carmody, Leonard Ely, H. R. McGraw, Benj. Matthews, V. D. McKelvey, J. M. Barney,

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Due credit for the few illustrations not original is given in the legends accompanying them.

The chapter on the use of the Röntgen ray is written by Dr. H. G. Stover, and most of the Röntgenograms have been taken for me by him, or have been drawn from his collection of over thirteen thousand plates.

MILLER E. PRESTON.

DENVER, COLORADO.

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PART I.

UPPER EXTREMITY.

FRACTURES AND DISLOCATIONS

CHAPTER I.

FRACTURES OF THE CLAVICLE AND INJURIES TO THE CLAVICULAR ARTICULATIONS.

The clavicle may be fractured by direct or indirect violence, or either end of the bone may be dislocated. The early ossification of the clavicle accounts for the frequency with which it is fractured in children, and the fact that the sterno-clavicular ligaments extend outward onto the diaphysis, explains the rarity of separation of the single clavicular epiphysis situated at the inner end of the bone. Dislocation of either end of the clavicle is rare as compared with fracture. Males are more subject to injury of this bone and its articulations because of their occupations, and heavier musculature. The coraco-clavicular ligaments are an important element in determining the site of fracture when due to indirect violence, and in limiting the displacement in both fractures and dislocations. The stability of either end of the clavicle depends on ligaments, rather than the conformation of the articular surfaces. The acromial end is dislocated nearly four times as often as is the sternal end, while all the dislocations of the clavicle make up about four percent of the luxations of the entire body. Dislocations of both ends of the bone, and simultaneous dislocations of both clavicles, are conditions which have been recorded, though they are extremely rare.

Injuries to the clavicle and its articulations will be taken up in the following order:

Dislocation of the sternal end.
  Forward.
  Backward.
  Upward.
Fracture of the clavicle.

Dislocation of the acromial end.
    Upward.
    Downward.
    Sub-coracoid.

Fracture of this bone is so common and dislocation so rare that examination of the ends of the clavicle is often neglected, especially in the presence of fracture. The fact should never be lost sight of that two or more lesions may be present at the same time. A systematic examination of the entire region should be made in addition to determining the condition of the bone in question. The surgeon should remember that the examination is not necessarily concluded with the finding of a given lesion; further damage may have been done to adjoining bones or joints. Particularly, care should be exercised in examining children because of the mild and indefinite character of the symptoms accompanying the fracture of the clavicle in the early years of life.

CHAPTER II.

DISLOCATIONS OF THE STERNAL END OF THE CLAVICLE.

Surgical Anatomy.—The articular end of the clavicle is much larger than the articular facet on the sternum, and the integrity of the joint is almost entirely dependent on the ligaments that surround the joint and bind the two bones together. The capsule is attached to the margins of the two articular surfaces and completely encloses the joint cavity. It is reinforced in front and behind by the anterior and posterior sterno-clavicular ligaments. To the inner side and above, it is overlaid by the interclavicular ligament which is attached to both clavicles. Externally the rhomboid ligament, extending from the under surface of the clavicle to the cartilage of the first rib, greatly strengthens the articulation. This ligament is in relation posteriorly with the subclavian vein. The ends of the bones entering into this articulation are very poorly adapted to each other and when dislocation takes place recurrence of deformity is prompt, unless prevented by retentive dressings. The rhomboid ligament is seldom completely torn and will tend to limit the displacement.

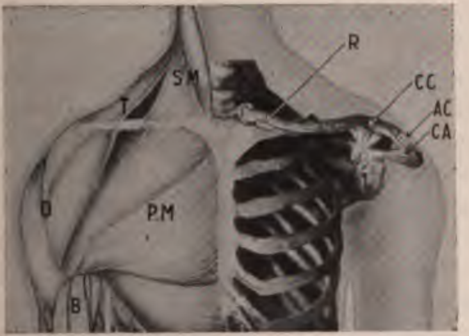

Fig. 1.—Muscular and ligamentous attachments of the clavicle. *T.*, trapezius; *S.M.*, sterno-mastoid; *D.*, deltoid; *P.M.*, pectoralis major; *B.*, biceps; *R.*, rhomboid ligament; *C.C.*, coraco-clavicular ligament; *A.C.*, acromio-clavicular ligament; *C.A.*, coraco-acromial ligament. The interclavicular ligament may be seen attached to the upper aspect of the inner end of the bone.

Displacement of the sternal end is usually the result of indirect violence. If the long axis of the clavicle is continued inward it will pass in front of the sternum, and accordingly the most common type of luxation of the sternal end is forward. The displacement may be partial or complete and accordingly the condition is spoken of as either a luxation or a subluxation. Forced backward displacement of the shoulder may produce a luxation of the inner end of the clavicle by leverage against the first rib.

Forward dislocation is by far the most common luxation seen at this joint, and is usually the result of the shoulder having been driven forcibly backward beyond the normal limitation of motion. If the shoulder be carried backward the inner end of the clavicle comes in contact with the first rib, and if forced still further backward this contact with the first rib acts as a fulcrum by means of which the inner end of the bone is torn away from the sternum and displaced forward. This mechanism seems to be the usual cause of displacement, though there are some instances in which the condition has taken place gradually and has apparently been the result of a general relaxation of the ligaments about the joint.

Backward luxations are not as common as the type just described, though they are next in order of frequency. They are usually the result of violence which forces the shoulder forward and inward, though they are sometimes caused by a direct force which drives the inner end of the clavicle backward. The trachea, œsophagus and the large vessels of the neck lie behind the inner end of the clavicle, and when a posterior displacement occurs any or all of these structures may be pressed upon.

Upward luxation of the sternal end of the clavicle is extremely rare and is usually the result of violence which depresses the shoulder. The ligaments are more or less torn according to the severity of the causative trauma. Luxations of the inner end of the clavicle are rare, as compared with fractures of the clavicle.

Symptoms.—Pain is more or less pronounced at the site of the lesion and is increased with motion of the shoulder. Loss of function varies with the completeness of the dislocation and the amount of pain suffered by the patient. There is more or less swelling about the inner end of the bone. The deformity varies with the direction of the luxation.

In *forward luxations* the inner end of the bone is more prominent than normal and is often found displaced downward onto the anterior surface of the sternum, as well as forward. The lowered position of the inner end of the bone changes the axis of the clavicle, which deformity can often be recognized by inspection alone.

In *backward luxations* it will be noted that the normal prominence of the inner end of the clavicle is absent, and the axis of the bone is changed. Palpation of the shaft of the clavicle will disclose the altered position. Passive congestion of the face on the side of the luxation may be present, and in severe cases cyanosis may be pronounced. Dysphagia and dyspnœa are not uncommon. The acuteness of these symptoms usually subsides even though the displacement be allowed to go uncorrected. There is no reported case of permanent injury to the structures thus pressed upon and accordingly these symptoms are not alarming. The shoulder is displaced downward and forward and is a little nearer the thorax than normal. This displacement is often slight and if the shoulder is not compared with the opposite side the deformity may go unrecognized.

In *upward luxations* there is a variable amount of disturbance in function and pain at the seat of injury. Inspection and palpation will show the change in the axis of the bone and the upward displacement of the inner end. The inner end of the bone is abnormally mobile.

Diagnosis.—The clavicle is subcutaneous throughout and the sternal notch may be palpated without difficulty. Accordingly displacements of the inner end of the bone are easily determined. Differentiation of fractures of the clavicle from luxations of the inner end presents no particular difficulty unless the swelling is pronounced. In fractures of this bone crepitus is almost invariably distinct, and the absence of this symptom in luxations is significant. The distance between the tip of the acromion and the middle of the suprasternal notch is lessened in both fractures and luxations. Dislocations of the inner end of the clavicle are not infrequently overlooked because of associated lesions which are more evident. The X-ray is of value as a routine measure but is seldom necessary to establish the diagnosis.

Treatment.—Reduction is, as a rule, easily accomplished but it is usually a difficult matter to retain the articular surfaces in their proper relations. Certain positions are known to be favorable in the prevention of the recurrence of deformity but the surgeon should determine for himself in each and every case just what position is most favorable in holding the articular surfaces in apposition.

In *forward luxations* the condition is easily recognized and there is little difficulty in reducing the displacement. Outward and upward traction on the shoulder with direct pressure on the end of the bone will usually be all that is necessary to effect reduction. The displacing action resulting from contact between the clavicle and first rib is avoided by preventing extreme backward displacement of the shoulder during the after-treatment. Any form of dressing which will properly immobilize the shoulder without carrying it too far backward will accomplish the desired result. When the ligamentous tearing has been extensive it may be necessary to employ some form of dressing which will support the weight of the upper extremity and overcome the action of the muscles which pull the shoulder downward, forward and inward. In accomplishing this purpose care should be exercised not to pull the shoulder too far backward. A figure-of-eight of both shoulders with the turns passing in front of the chest, and another figure-of-eight with the turns across the back will fix the shoulder sufficiently for all practical purposes. A plaster of Paris spica will immobilize the shoulder very perfectly but is seldom necessary. It is often advisable to employ direct pressure over the sternal end of the clavicle by means of pads and strips of adhesive plaster. When pressure is used in this way it should be remembered that the end of the bone is subcutaneous and that sloughing of the skin may follow if the pressure is too severe or too long continued. It is probably better to exert the pressure over the inner two inches of the shaft rather than directly over the end of the bone. The necessity for direct pressure will depend on the tendency to recurrence of deformity after the shoulder has been fixed. There is probably no dressing which will perfectly fill all requirements in all instances. Each case must be considered by itself and the particular dressing employed is of secondary moment, provided the shoulder is immobilized with the luxation in reduction and in a position showing the least tendency to the recurrence of deformity. It will be found practically impossible to entirely correct the anterior displacement, but absolute reduction is not essential to complete restoration of function, and the slight deformity remaining is of little moment.

Young women may be desirous, for cosmetic reasons, of securing as perfect reduction as possible, and in such instances the shoulder should be fixed and the displacement treated in the recumbent position for a period varying from ten days to two weeks.

In *backward dislocations* of the inner end of the clavicle reduction is accomplished by traction upward, outward and backward, and is, as a rule, attended by little difficulty. If additional manipulation is required the clavicle may be grasped in its middle third, where it is free from heavy muscular attachment, and direct traction made to replace the inner end of the bone as the shoulder is being pulled outward and backward. Reduction is much more easily maintained than in the forward variety, though the shoulder should be immobilized and the case kept under observation as in forward dislocations. The shoulder may be immobilized by the double figure-of-eight as already described, or the Velpeau or Sayre dressing may be employed. (See Figs. 30 to 35.) Direct pressure over the inner end of the bone is seldom required in this form of luxation.

In *upward luxation* of the sterno-clavicular joint, reduction is accomplished by outward traction on the shoulder accompanied by direct downward pressure on the inner end of the clavicle. Maintaining the end of the bone in proper position is attended with difficulty here, as in other types of luxation at this joint. The shoulder should be immobilized and the arm supported to prevent downward displacement. If there is much displacement of the clavicle it may be well to place a pad in the axilla, and bind the arm to the side to maintain the proper distance of the shoulder from the thorax. The principles involved in the treatment of this dislocation are similar to those already described in the two preceding types of luxation.

Operative Treatment.—Operative intervention is, as a rule, indicated only in old cases with loss of function, and in cases of recurrent dislocation which have not responded to non-operative measures. Proper reduction can almost invariably be had in recent cases by proper fixation, but should recurrence of deformity take place in spite of appropriate dressings, it may be advisable to expose the end of the bone and secure it in position with suture.

An incision parallel to the clavicle is made exposing the parts; the end of the clavicle is then dissected out from the fibrous tissue which surrounds it in its displaced position in old cases. It is then returned to its proper relation with the sternum and fixed in position. It may be possible in some cases to repair the ligaments sufficiently to retain the end of the bone in place. In other instances it may be necessary to drill holes in the end of the clavicle and the upper end of the sternum and prevent recurrence by some form of suture material, either absorbable or otherwise. The relation of the great vessels of the neck should be kept in mind when operating in this region. In cases of recurrent or habitual dislocation a repair of the ligaments will frequently be all that is required. The same results have been obtained by the repeated injection of small quantities of alcohol in the region of the anterior sterno-clavicular ligament, thus producing inflammatory reaction and secondary fibrosis. Resection of the articular end of the clavicle, with the subsequent formation of a false joint, is a method which has been followed by excellent results in habitual luxations.

Operative treatment is rarely indicated in backward or upward luxations, but should the necessity arise for open treatment in either type the principles will be the same as already given.

After-Treatment.—In simple cases the retentive dressings may be dispensed with at the end of a month, and pressure over the sternal end is seldom of use after ten days to two weeks. During the progress of the case the dressings should be examined frequently to correct alteration in position, and when pressure is employed the parts should be carefully watched so that irritation of the skin may be immediately detected if it appears. Activities subjecting the articulation to much strain should be avoided for another month to six weeks following removal of all dressings. When these simple details are followed the patient will almost invariably make a perfect functional recovery, though there is usually some prominence remaining at the site of the dislocation. The after-treatment is the same in all forms of luxation of the sterno-clavicular joint.

Prognosis.—With proper reduction and immobilization restoration of function should be practically complete. If the end of the bone is allowed to remain in displacement there will be more or less loss of function. If strain is placed on the joint too soon following the initial luxation the condition may become recurrent.

CHAPTER III.

FRACTURES OF THE CLAVICLE.

Surgical Anatomy.—The clavicle is the most frequently broken single bone in the entire body, and this fact renders a study of its anatomy particularly advisable. This fracture is especially common in children. The clavicle is the only bone connecting the upper extremity with the trunk, and its position is quite superficial. These two facts expose the bone to fracture, both from direct and indirect violence. The most common fracture is the result of indirect violence and the break is usually situated at or near the junction of the outer and middle thirds where the two curves of the shaft meet, and the bone changes in form from "prismatic" to "flat."

The shaft of the clavicle is well ossified before birth, and the bone has but one epiphysis which is situated at the sternal end. This single epiphysis begins to ossify at about the eighteenth year and joins the shaft during the twenty-fifth year. The ligaments of the sterno-clavicular articulation extend beyond the epiphysis and are attached to the shaft of the bone so that epiphyseal separations are almost never seen.

The clavicle is situated in a muscular plane which should be understood to appreciate the displacements which take place when fracture occurs. On the inner end of the bone is attached the clavicular origin of the sterno-mastoid above, while opposite it on the anterior and lower aspect of the bone is attached the clavicular origin of the pectoralis major. In the presence of fracture in the usual site, it might seem that these muscles would counteract each other, but if the direction of the fibres of these two muscles is observed it will be noted that those of the pectoralis approach the bone at an acute angle, while the clavicular head of the sterno-mastoid is placed at nearly right angles with the shaft. This gives the sterno-mastoid the mechanical advantage, and accordingly the inner fragment is displaced upward. The subclavius is attached to the inferior surface of the shaft, in its middle third, and when the bone is broken and depressed against the first rib and the structures passing into the axilla, it acts, to some extent, as a cushion. To the anterior border of the outer third is attached the deltoid, and on the posterior border of the same corresponding portion of bone is found the clavicular insertion of the trapezius. These two muscles about balance each other and are seldom responsible for displacement of fragments. The ligaments of the clavicle play an important part in preventing and limiting displacement of the fragments. The rhomboid ligament is a heavy structure which passes from the first costal cartilage to the under surface of the inner end of the clavicle. The sterno-mastoid usually displaces the inner fragment upward until this ligament becomes taut, when further deformity is checked. When the fracture lies internal to the coraco-clavicular (coronoid and trapezoid) ligament the inner fragment is free to move upward, while the outer fragment falls downward, inward and forward with the shoulder. When the fracture passes through this ligament both fragments remain attached to the coracoid and displacement is slight or absent. Fractures of the clavicle between the coraco-clavicular and acromio-clavicular ligaments are usually not accompanied by much deformity.

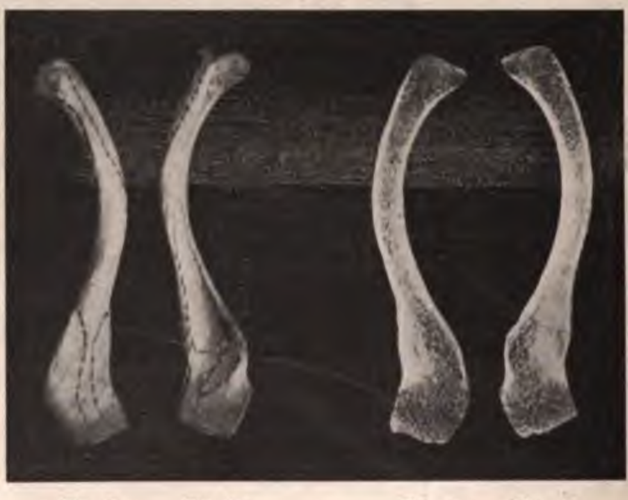

Fig. 2. Fig. 3. Fig. 4. Fig. 5.

Figs. 2 and 3 show the superior surfaces of the right clavicle. Dotted lines indicate the margins of muscular and ligamentous attachments.

Figs. 4 and 5 show the internal structure of the same bone. Note the preponderance of compact tissue in the shaft and region corresponding to the oblique line.

It is not often necessary to operate on the clavicle, but when the occasion does arise the surgeon should appreciate the internal structure of the bone. Figs. 4 and 5 show a horizontal section of the bone. The clavicle is composed largely of compact tissue, the cancellous bone being confined to the extremities. The compact tissue is particularly heavy in the region of the oblique line where the coraco-clavicular ligaments are attached.

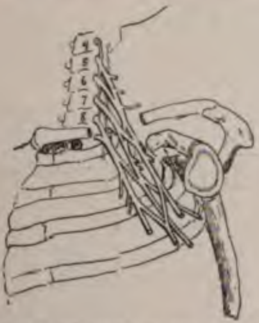

Fig. 6.—Diagram showing the relations of the brachial plexus to the first rib and clavicle. Section of clavicle removed.

The clavicle is subcutaneous throughout and easily palpated. It should be noted that the acromion stands directly external to the outer end of the bone, as well as behind it. The rounding of the outer aspect of the shoulder is caused by the head of the humerus beneath the deltoid, and not by either clavicle or acromion.

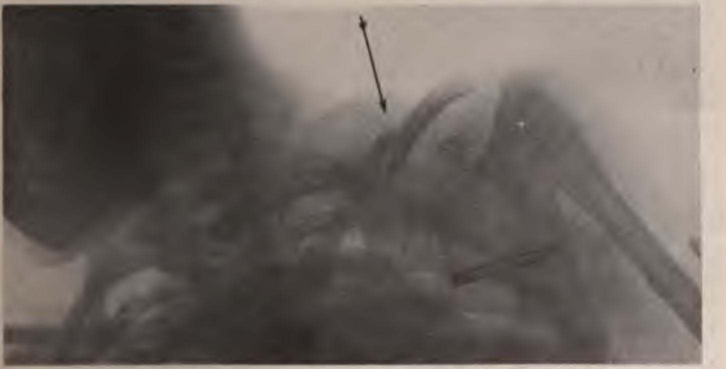

Fig. 7.—Fracture of the clavicle with overriding deformity in a child.

Any portion of the clavicle may be broken, but by far the most common site of fracture is in the outer end of the middle third and is decidedly oblique. Fracture in this region is usually the result of indirect violence and is almost always produced by a fall on the shoulder. Trauma sustained in this way more often produces a dislocation of the shoulder in adults, while in children fracture is more common because the clavicle is relatively weaker. Incomplete fracture is common in children. Fractures in either the

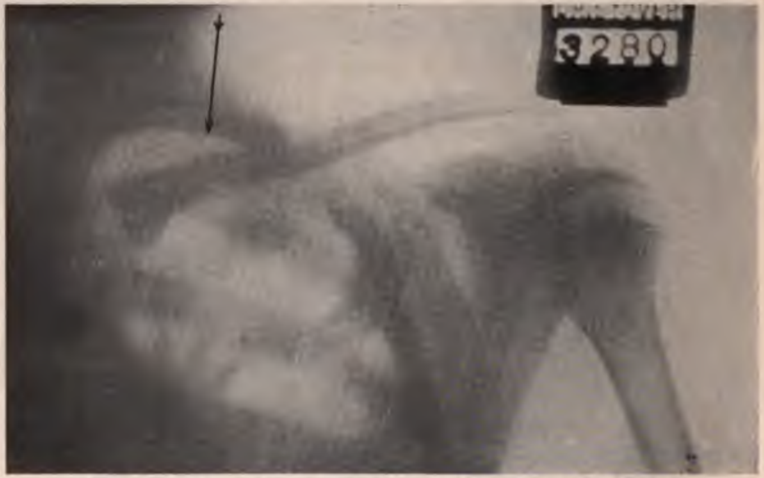

Fig. 8.—Fracture of the clavicle in its inner third. No deformity.

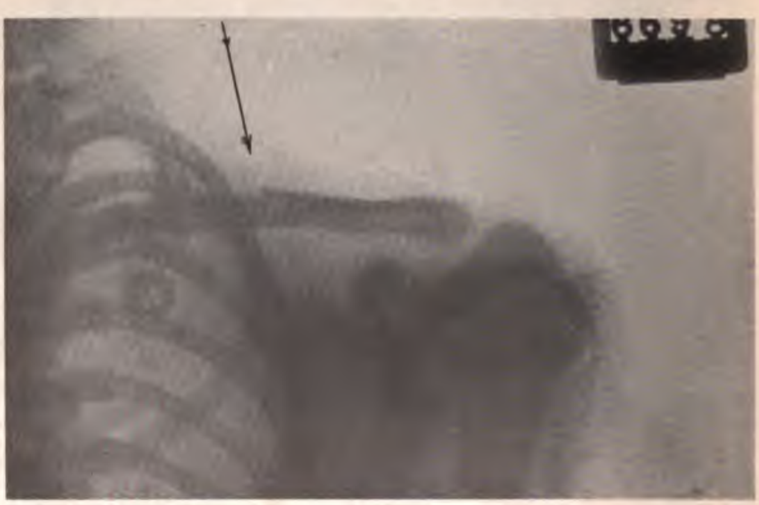

Fig. 9.—Green-stick fracture of the clavicle.

inner or outer third are comparatively rare and usually the result of direct violence. Muscular action is sometimes, though rarely, responsible for fracture of the clavicle.

It should be remembered that fracture internal to the coraco-clavicular ligament completely destroys all bony and ligamentous connection between the scapula and sternum, but when the break occurs through, or external to, this ligament, a heavy bond is maintained between the inner fragment and the shoulder blade. Simultaneous fracture of both clavicles is occasionally seen as a result of transverse crushes of the shoulders.

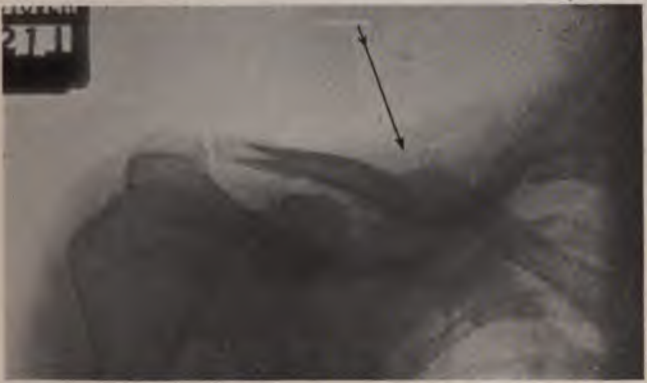

Fig. 10.—Fracture of the middle third of the clavicle with the usual deformity—upward displacement of the inner fragment.

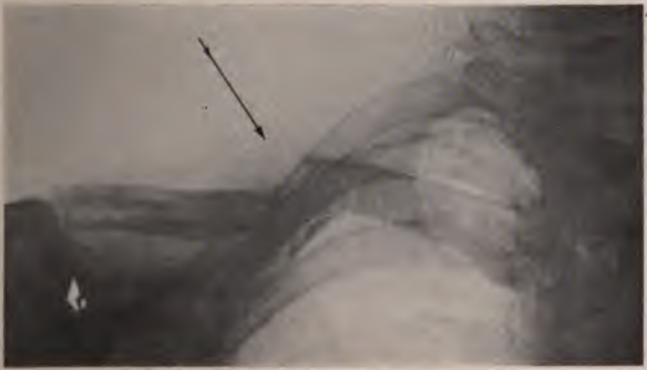

Fig. 11.—Fracture of the clavicle with the usual deformity.

Symptoms.—The patient complains of pain immediately following the accident, and there is almost complete loss of function

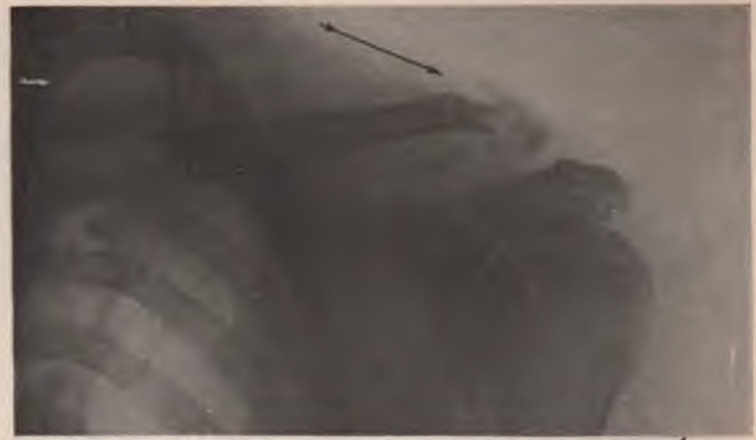

Fig. 12.—Comminuted fracture of the outer end of the clavicle (rare).

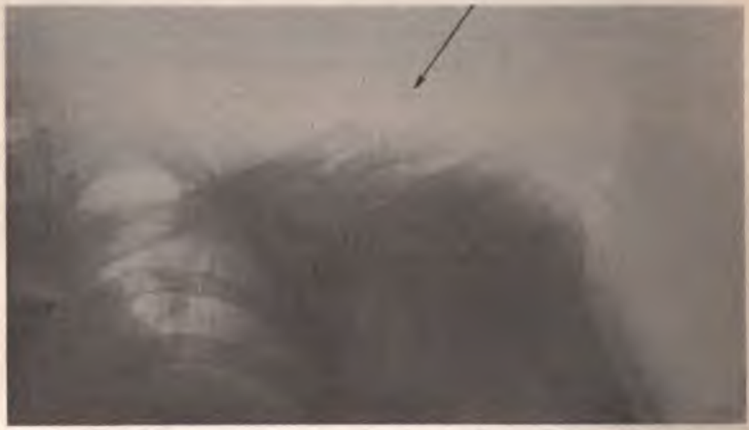

Fig. 13.—Comminuted fracture of the clavicle with overriding.

as a result of pain and of the disturbed mechanism of the shoulder. Swelling usually develops within a few hours and obliterates the supra- and infra-clavicular fossæ. The surgeon can hardly fail to recognize the obliteration of these fossæ if the opposite shoulder is inspected and compared. If the inner fragment is free of the coraco-clavicular ligament the deformity will be so pronounced that the nature of the injury should be recognized by inspection alone. The shoulder is displaced inward, forward and downward, the injured member is supported with the opposite hand and the head is inclined to the injured side to relax the pull of the sterno-mastoid. The patient is unable to draw the shoulder forward, as shown in normal cases in Figs. 27 and 28. The inner fragment is usually

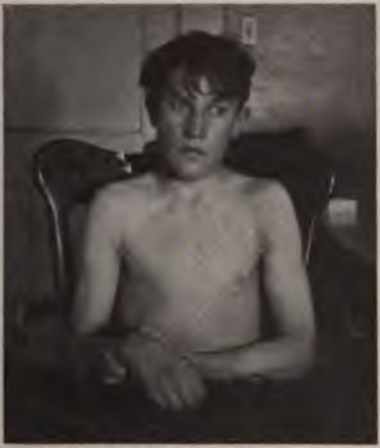

Fig. 14.—Fracture of the right clavicle about twenty minutes after the accident. The injury was sustained by a fall on the shoulder. Note the swelling in the region of the fracture and the slight falling of the shoulder. The manner in which the patient grasps and supports the injured member is characteristic. If need be the diagnosis might be made by inspection alone. Palpation reveals abnormal mobility and crepitus at the site of fracture.

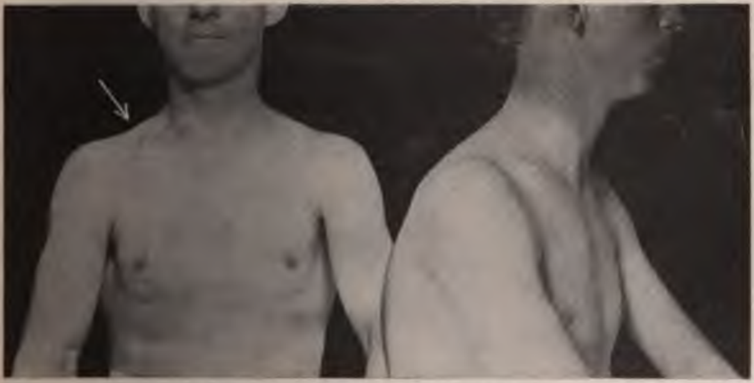

Fig. 15. Fig. 16.

Figs. 15 and 16.—Front and side views of fracture of the clavicle with moderate deformity. Note the prominence produced by the outer end of the inner fragment. Photographs taken about thirty minutes following the accident.

displaced upward and can, as a rule, be palpated and moved without difficulty. The nearer the fracture is situated to the inner third of the bone the more pronounced will be the angle of upward displacement. The distance between the supra-sternal notch and the acromion process is decreased on the injured side; in other words the shoulder is shortened. When the fracture lies through or external to the coraco-clavicular ligament the deformity will usually be too slight to recognize by inspection, and the patient will

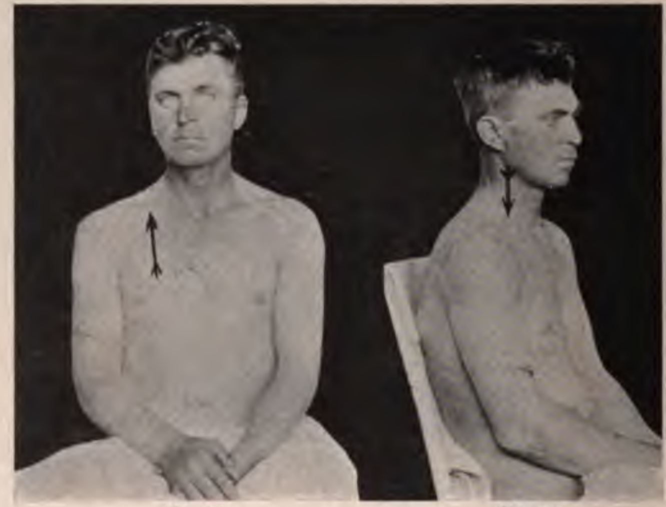
Fig. 17. Fig. 18.

Figs. 17 and 18.—Fracture of the right clavicle at about its middle. Note the prominence of the outer end of the inner fragment. Photographs taken about twenty minutes following the accident.

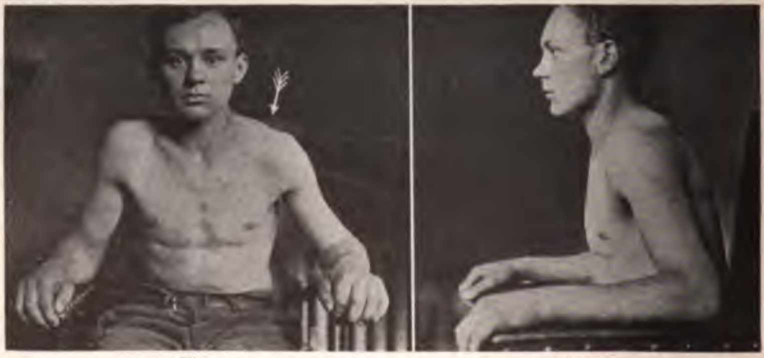
Fig. 19. Fig. 20.

Figs. 19 and 20.—Fracture of left clavicle about twenty-four hours following injury. Note the falling of the injured shoulder and the swelling which obliterates the supra- and infra-clavicular fossæ. The side view shows the forward displacement of the shoulder which is common in fractures of this bone.

not show the usual anxiety in supporting the injured member. Pain, local tenderness and less pronounced loss of function will, however, be present. If the surgeon fixes the shoulder with one hand, the fingers of the opposite hand will detect abnormal mobility by alternate forward and backward pressure on the clavicle, in the region of the fracture. The middle third of the clavicle is free from heavy muscular attachments and can be grasped without difficulty in testing the integrity of the bone. When the normal

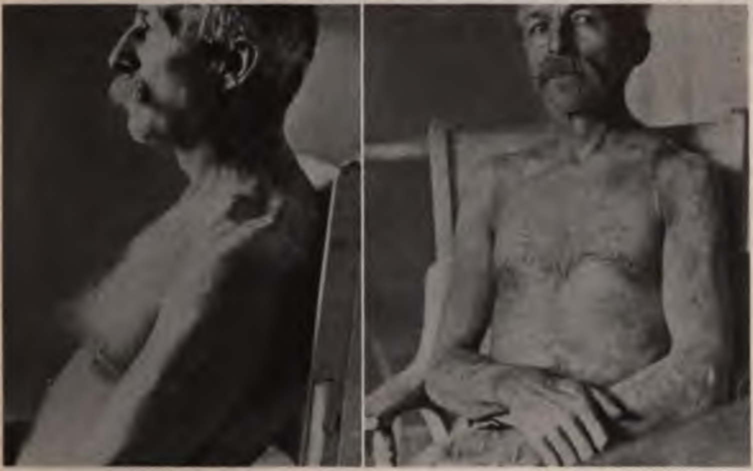

Fig. 21. Fig. 22.

Figs. 21 and 22.—Fracture of the left clavicle with pronounced upward displacement of the inner fragment which is not bound down by the coraco-clavicular ligament. The following points are significant in making a diagnosis from inspection alone: Contour of shoulder normal, axis of arm normal, shoulder as a whole slightly lowered and patient grasps forearm. Deformity of clavicle plainly visible as well as palpable. Photographs taken a few minutes following the accident.

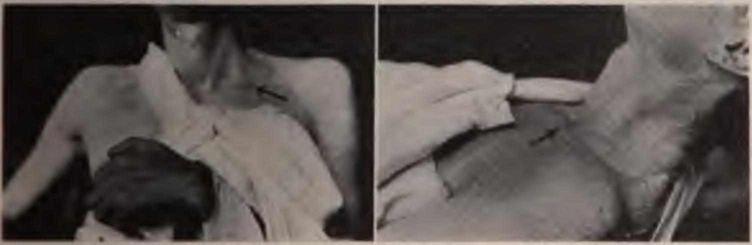

Fig. 23. Fig. 24.

Figs. 23 and 24.—Delayed union of clavicle due to poor approximation of fragments. The inner fragment is above and anterior to the external fragment. This deformity is chiefly the result of the action of the clavicular attachment of the sternomastoid. Fracture nearer the median line than usual. Injury the result of direct violence. Patient first seen by author six weeks after the accident.

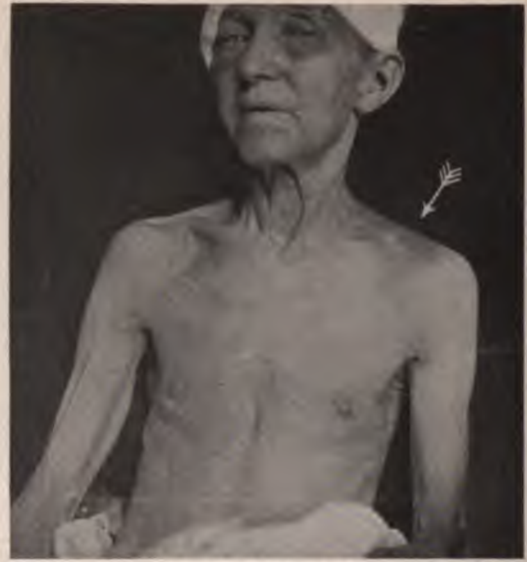

Fig. 25.—Fracture of the left clavicle in an elderly woman some days following the accident. Note the ecchymosis in the region of the fracture and the obliteration by swelling of the supra- and infra-clavicular fossæ. Falling of shoulder not apparent because elbow is supported by the arm of the chair.

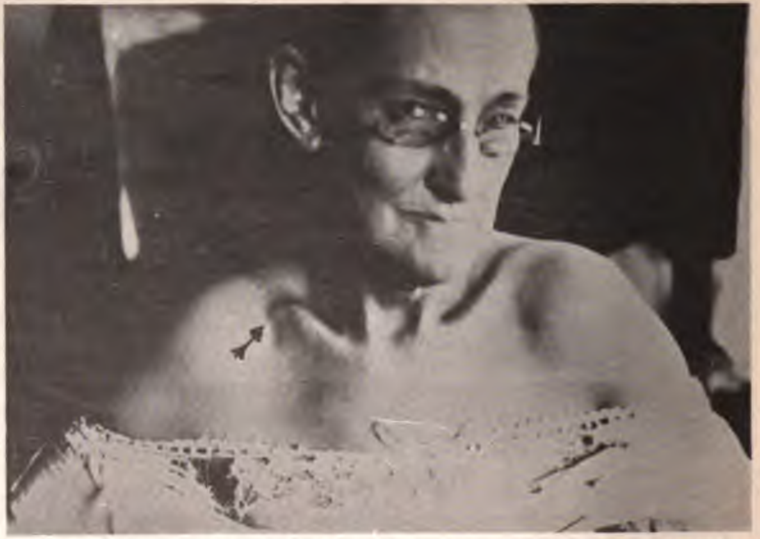

Fig. 26.—Fracture of right clavicle with pronounced deformity following improper treatment. This case (according to the history given by the patient) was treated by means of a plaster cast of the shoulder and the deformity recognized only when the dressing was removed some weeks later. Function of shoulder much impaired and symptoms of brachial plexus irritation present. This condition is a striking example of what may follow treatment which is not based on proper principles.

shoulder is thrown, forward this middle third stands out prominently as shown in Figs. 27 and 28.

Ecchymosis usually develops within the first day or two and is almost pathognomonic of fracture.

In children the fracture is often incomplete and the symptoms are much less pronounced. Local tenderness and pain are present but the child may not show any perceptible disturbance in the use of the arm and hand. More commonly, however, there is a disinclination to use the hand of the injured side and the patient will cry out when the arm, forearm or shoulder is manipulated. Local swelling is usually present. When the fracture is complete the symptoms will be more pronounced though deformity is almost always slight in children.

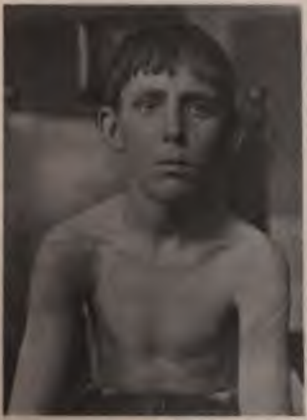

Fig. 27.

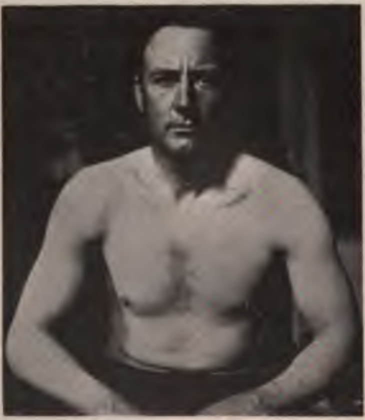

Fig. 28.

Figs. 27 and 28.—These two pictures were taken to demonstrate the manner in which the outlines of the clavicles may be brought out by throwing the shoulders forward. This movement not only brings out the outline of the bone but shows whether or not the clavicle is properly performing its function. If the clavicle is fractured the action of the shoulder will be quite different when the patient is requested to throw the shoulder forward. In adipose and well-muscled persons it is more difficult to see the outline of the clavicle, yet the signs and symptoms of fracture are almost always sufficiently pronounced to form a diagnosis if the examiner is observant and systematic.

Fracture of the clavicle is rarely compound and injury to the structures passing beneath the clavicle are rare, considering the frequency with which the clavicle is fractured. If the brachial plexus or axillary artery is injured symptoms of paralysis or nerve irritation or disturbance in the circulation of the upper extremity will develop.

Crepitus is a symptom which can almost always be elicited in fractures of the clavicle, except in the incomplete form occurring in children.

Diagnosis.—There is, as a rule, little difficulty in recognizing fracture of the clavicle if the region of the shoulder is carefully examined. The diagnosis is based on the symptoms just given. Incomplete fractures in children, and fractures of the outer end of the bone are most likely to be overlooked. In establishing a diagnosis of fracture of the clavicle it is not sufficient to note the presence of a break in a given region, but the entire shoulder should be examined to exclude associated lesions. The clavicle should be palpated from end to end; occasionally the fracture is multiple. The spine of the scapula and the acromion should be palpated and the condition and position of the upper end of the humerus should be determined. The circulation of the forearm should be examined and the reflexes noted.

Treatment.—Reduction of the deformity in fractures of the clavicle is usually a simple matter, being accomplished by pulling the shoulder outward, upward and backward. The deformity recurs, however, as soon as the parts are released. Correction of the displacement, therefore, is useless prior to the application of retentive dressings.

Innumerable dressings have been devised for maintaining the fragments in reduction, but only those which have proven most satisfactory will be considered.

The modified Sayre adhesive plaster dressing will be found most satisfactory in the largest number of cases and is applied with three strips of adhesive plaster, each about four inches wide and long enough to encircle the trunk one and a half times. Zinc-oxide plaster should be used as it is less irritating. Before the adhesive is applied the axilla should be cleansed, and the arm and chest sponged with alcohol and thoroughly dried. A folded towel should be placed in the axilla or a few layers of gauze secured in position to prevent the arm from coming in contact with the chest. If the upper extremity is immobilized and skin is allowed to come in contact with skin, cutaneous irritation is almost sure to follow and may be severe. A light folded towel or folded gauze should also be placed about the middle of the arm before the first strip of adhesive is applied.

The first strip of adhesive encircles the arm (the loop being secured with a safety pin) half way between the shoulder and elbow; the strip is then continued under tension, across the back, under the opposite arm and on to the chest anteriorly. This strip of adhesive, when in place, should pull the arm well backward. The portion of the dressing encircling the arm should be equidistant from the shoulder and elbow; neither above nor below this point. *The second strip* begins behind the shoulder, extends down the back of the arm, under the elbow, along the dorsal surface of the forearm and hand, and over the opposite shoulder. As this strip passes under the elbow the adhesive should be split and a generous padding of cotton placed in position to prevent irritation at the point of the elbow. As the end of the strip is being attached to the opposite shoulder the hand should be raised on the chest and the elbow pulled forward. This second strip pulls the elbow forward (thus displacing the shoulder backward with the middle of the arm fixed by the first strip) and raises the entire arm. When these two straps are in position the shoulder is pulled upward, backward and outward, thus meeting the requirements for reduction of the displaced fragments. *A third strip of adhesive plaster* is then passed horizontally around the chest and arm to fix the arm to the side. Instead of this strip a body-swathe may be used to steady the member. This dressing, when properly applied, immobilizes the shoulder most satisfactorily. The author has found, however, that the patient usually complains of the confinement of the hand which often shows considerable irritation

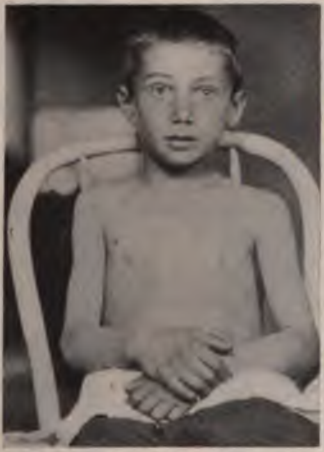

Fig. 29.—Fracture of the right clavicle with the usual symptoms. The following figures show the application of a modified Sayre's dressing to this case.

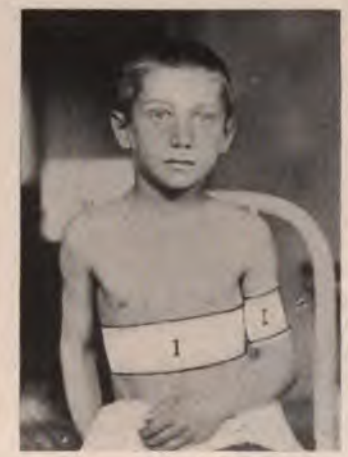

Fig. 30.

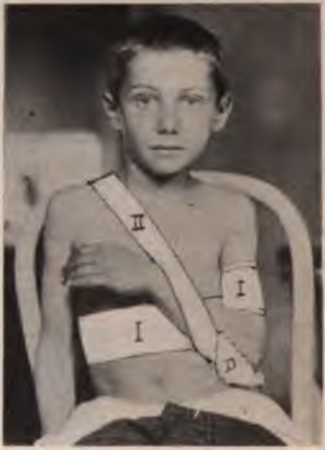

Fig. 31.

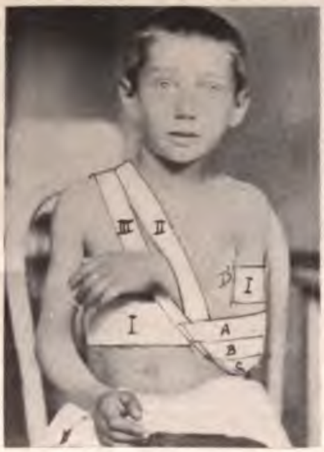

Fig. 32.

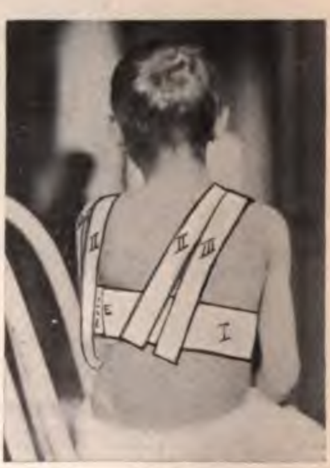

Fig. 33.

Author's modification of a Sayre's dressing applied to the fractured clavicle shown in Fig. 29. In this dressing the hand is not included, which is a great comfort to the patient and does not render the dressing less effective. Sayre's dressing will meet the indications better in the greatest number of cases. When employed in the treatment of children, special care should be taken in watching for signs of irritation to the delicate skin. (See Figs. 37 and 38.—The Taylor brace, which is of great advantage in the treatment of children.)

Fig. 30.—First strap of adhesive encircles the arm and then the body, pulling the arm backward.

Fig. 31.—Second strap of adhesive passing down the posterior aspect of the arm, under the elbow and over the opposite shoulder.

Fig. 32.—Third strap of adhesive which passes down the outer side of the arm, under the elbow and under the hand to the opposite shoulder.

Fig. 33.—Another view of the dressing showing the attachment of the straps posteriorly.

where it comes in contact with the adhesive. To obviate this the author has been in the habit of dividing the second strip into two narrow strips applied as shown in Figs. 32 and 33. The first strip passes down the posterior aspect of the arm, under the elbow, and then diagonally across the forearm so that it passes above the hand and over the opposite shoulder. The second strip passes down the outer side of the arm, under the elbow on its outer aspect, and then diagonally across the forearm in the opposite direction so that it passes below the hand and over the opposite shoulder. The hand is thus left exposed and free from irritation, and the patient may move it at will, thus relieving the discomfort of the cramped position without in any way disturbing the fixation. (See Figs. 29 to 33.) In some instances, especially when the fracture is in the inner half of the bone, additional direct pressure may be necessary to prevent upward displacement of the inner fragment. This is accomplished by means of pads of gauze or cotton held in position by strips of adhesive.

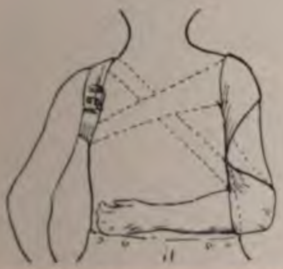

Fig. 34.—Mohr's figure-of-eight.

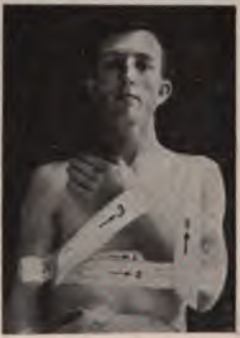

Fig. 35.—Shows the turns used in Velpeau's bandage.

When adhesive plaster is not available Mohr's figure-of-eight, Velpeau's bandage or a posterior figure-of-eight with the turns passing behind the shoulders will serve the purpose as an emergency dressing. These dressings, however, are all too insecure to be relied upon in permanent fixation of the clavicle.

The recumbent position will almost invariably maintain the fragments in good position when all forms of ambulatory treatment prove inefficient. The patient should be placed on a firm narrow bed, the arm secured to the side by means of a swathe, and a small firm pillow placed between the scapulæ and fixed in position on the back by means of strips of adhesive. Multiple fracture of the clavicle or simultaneous fracture of both clavicles can be successfully treated by this method. (See Fig. 36.)

The test of any dressing is the position occupied by the fragments and the absence of undue constriction of the arm and forearm. No matter what method is employed either the presence of deformity or strangulation of the upper extremity is a condition which calls for correction and indicates the inefficiency of the dressing.

In adults, especially large persons, considerable strength is necessary in the dressing to maintain the proper position of the upper extremity, and accordingly the points of greatest pressure (the middle of the arm and the point of the elbow in Sayre's dressing) should be particularly well padded.

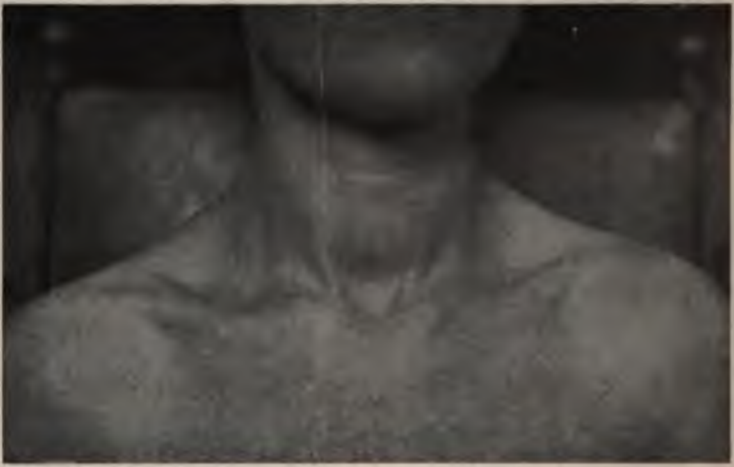

Fig. 36.—In difficult cases recumbent treatment will give good results when other methods would fail. This photograph was taken about five years after fracture of both clavicles (one clavicle in two places) and fracture of the first and second ribs on both sides. Recumbent treatment was employed. At the time this photograph was taken it was impossible to determine by palpation the former positions of the fractures in the clavicles.

Taylor's brace (see Fig. 37) is especially well adapted to fractures of the clavicle in children, and allows freedom of motion of both arms. Sayre's dressing, however, will answer the purpose very well, though the delicate skin of a child must be closely watched for irritation when adhesive plaster is employed.

Operative Treatment.—Nearly all cases of fractured clavicle can be successfully treated either by Sayre's dressing or the recumbent method and hence operative intervention is rarely indicated in recent cases. When, however, operation is demanded a single loop of suture material will usually accomplish all that is required to hold the fragments in position; the Lane plate is almost never needed. The incision is best made a little below and parallel to the bone, rather than directly on it. If the incision is a little below the clavicle a short flap may be made, and the danger of infecting the wound from the cut skin edges will be lessened.

Most surgeons prefer absorbable suture material (such as kangaroo tendon) to wire, in securing the ends of the fragments. In operating on the inner end of the bone the surgeon should have in mind the relations of the important structures passing between the clavicle and the first rib. The subclavian vein lies directly behind, and in contact with, the clavicle and subclavius muscle, and just external to and behind the rhomboid ligament. A little external to the vein and separated from it by the scalenius anticus is the subclavian artery, which is also in relation with the clavicle and subclavius muscle. If the surgeon does not exercise great care either of these vessels may be injured, thus giving rise to serious and troublesome hemorrhage. External to the artery is the brachial plexus descending from the neck into the axilla. Fortunately however fracture of the clavicle in the region of these structures is rare.

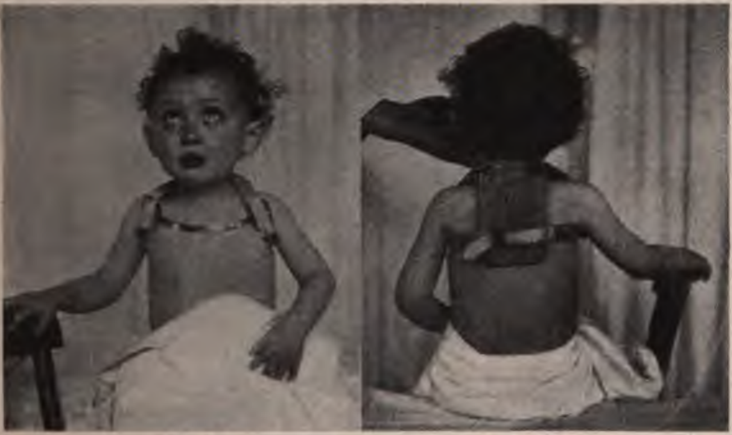

Fig. 37. Fig. 38.

Figs. 37 and 38.—The C. F. Taylor brace which is particularly satisfactory in the treatment of fractures of the clavicle in children.

Operation is sometimes demanded in old cases because of injury to the brachial plexus with resultant paralyses. These injuries are usually due to pressure alone (without laceration of the nerves) and if the condition is not too old removal of pressure, by dividing the bone and raising the depressed fragment, will be all that is required. Following operation it will, as a rule, be wise to fix the parts with a Sayre's dressing to relieve the internal fixation of as much strain as possible.

After-Treatment.—Sayre's dressing is the most secure known, yet it requires watching from day to day to correct slipping and to take up the slack as it develops. The fact that reduction is perfect and immobilization is secure after the dressing is in place should not lead the surgeon to assume that the same conditions will prevail a week later.

Most text-books advise the removal of the dressing at the end of a few days to inspect the skin for evidences of irritation and to see that reduction is maintained. This will seldom be needed if the dressing has been properly applied in the first place. Additional strips of adhesive following the course of the "second strip," as described in the application of Sayre's dressing, may be used as needed to raise the elbow and correct the downward slipping. The case should be carefully watched for signs of cutaneous irritation, strangulation of the circulation of the arm and for the partial recurrence of deformity.

In the uncomplicated case in a child, union may be expected at the end of two and a half or three weeks, though the callus at this time is in no condition to withstand any considerable strain. In adults a month or a little more is necessary for the fragments to unite. The dressings may be removed at the end of three to five weeks, according to the age of the patient, and the arm carried in a sling for another week or ten days. During the after-treatment the dressing should be changed every ten days and the parts carefully inspected and cleansed. In removing the dressing the patient is best placed in the recumbent position so that the clavicle will not be subjected to strain during the change from the old dressing to the new. Care should be exercised not to pull the shoulder forward as the old dressing is being removed and the new one applied. With the upper extremity released it is well to fully extend the elbow and gently abduct the shoulder without disturbing the clavicle. This will aid in keeping these joints free, and will be followed by more rapid resumption of function when the dressings are permanently removed. If the dressings are replaced in the sitting position the surgeon should have an assistant to confine his entire attention to holding the shoulder upward, backward and outward while the dressings are being changed. Massage and passive motion should be instituted as soon as the dressings are permanently removed, but care should be exercised not to submit the clavicle to strain before the callus is well formed. These measures are of the greatest value in keeping up the tone of the muscles and in maintaining the integrity of the articular surfaces following operations on the nerves, pending the regeneration of these structures.

Prognosis.—In the usual fracture of the clavicle complete restoration of function and strength should follow proper treatment. If the fragments have been allowed to unite in deformity there will be some loss of function, varying with the degree of deformity, and if the brachial plexus is impinged upon there may be a more or less complete paralysis of the upper extremity. If the disturbance in function is due simply to mechanical causes surprising improvement may take place as the years go by. The complication most often rendering the prognosis bad is injury to the brachial plexus. When this structure is damaged the outlook will depend on the nature and extent of the injury, and the length of time the paralysis has been established. With paralysis existing a year or two there is little chance of improving the condition by operation, but even under these circumstances there is everything to gain and nothing to lose, and it is advisable, therefore, to expose the plexus and do what can be done by relieving pressure and suturing divided nerve ends. In recent cases the prognosis is not bad if operated early, although the process of regeneration may extend over months or even a year.

In the uncomplicated case of fracture of the clavicle the prognosis is good whether in child or adult, provided proper treatment is carried out.

CHAPTER IV.

DISLOCATIONS OF THE OUTER END OF THE CLAVICLE.

Surgical Anatomy.—The acromio-clavicular articulation is of the arthrodial type and is composed of two small, nearly flat, oval facets, one on the acromion and the other on the outer end of the clavicle. The plane of this articulation is not at right angles with the long axis of the clavicle but is so placed that the clavicular facet looks downward, outward and backward. The result then (when the acromion is forced inward toward the base of the neck) is that the clavicle will tend to slip upward onto the top of the acromion. Violence of this type, however, is more likely to produce fracture of the clavicle than dislocation of either end. An inter-articular fibro-cartilage is sometimes present between the two articular facets. The joint depends entirely on the ligaments surrounding it and those passing between the coracoid and the clavicle. The coraco-clavicular ligaments play an important part in reinforcing this joint and are usually torn when the displacement is pronounced.

Nearly all the dislocations of the acromio-clavicular joint are of the upward type. About a dozen cases of downward luxation have been reported. Another form of dislocation is one in which the clavicle is displaced downward and forward beneath the coracoid process, but the few cases reported are questionable and the type is doubtful.

The upward luxation is described as complete or incomplete, according to whether or not the articular facets clear each other. The acromio-clavicular ligaments are more or less completely torn, and the coraco-clavicular ligaments may be partially or completely ruptured, depending on the extent of the displacement and the degree of violence.

Direct violence is usually responsible for luxations of the acromio-clavicular joint, though muscular action is known to have produced the condition. A downward blow on the acromion may displace this process downward while the clavicle is prevented, to some

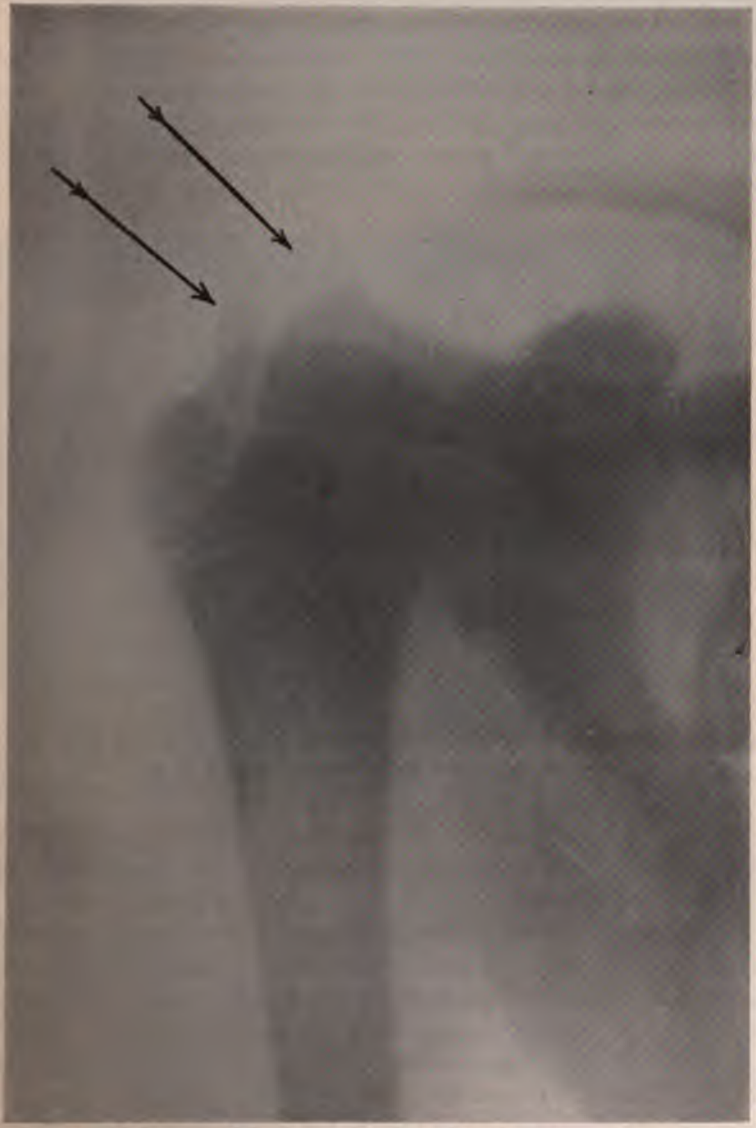

Fig. 39.—Dislocation of the outer end of the clavicle and separation of acromial epiphysis. The lower arrow points to the displaced epiphysis.

extent, from accompanying it by the action of the trapezius. The same type of violence which produces fracture of the clavicle may in rare instances be responsible for luxations of the outer end.

Symptoms.—Dislocations of the clavicle vary with the direction of the displacement and the extent of ligamentary rupture. There is always more or less pain in the region of the acromio-clavicular articulation which is increased by both active and passive motion of the shoulder. Disability varies greatly in different cases. Complete loss of function may be present in some cases while in others the patient may be able to use the shoulder, though the action of the part is more or less restricted by pain. It is probable that this variation in disability depends largely on the extent of laceration in the coraco-clavicular ligaments. The nature of the deformity varies with the type of luxation.

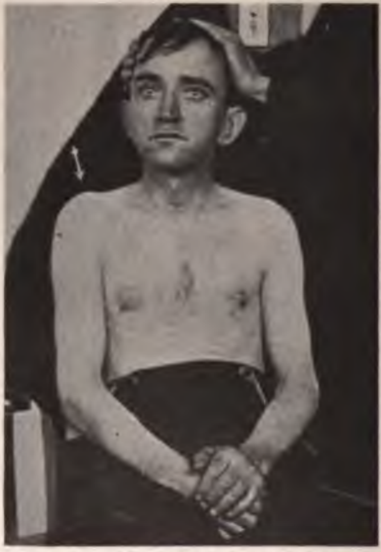

Fig. 40.—Dislocation of the outer end of the clavicle a few minutes following the accident. Note the prominence indicated by the arrow.

In the common upward variety a distinct prominence is noted at the outer end of the clavicle. In the incomplete form the prominence of the displaced outer end is not great, being as a rule less than the thickness of the bone. In the complete form the outer end of the bone stands out prominently and may be moved about on palpation. By pressing on the outer end of the clavicle and raising the shoulder, the prominence may be made to disappear as the luxation is reduced. Recurrence of deformity is prompt with release of the shoulder. A rotary displacement of the scapula is noted in some instances; the tip of the body being more prominent than normal, while the spine and acromion are depressed. If the clavicle is grasped in its middle third, where it is free from heavy muscular attachments, and manipulated, pain will be produced at the outer end.

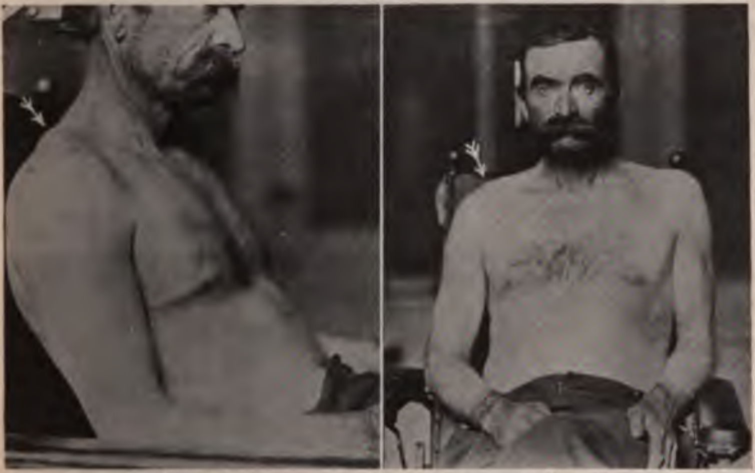

Fig. 41. Fig. 42.

Figs. 41 and 42.—Dislocation of the acromial end of the clavicle shortly following accident. Note the forward and downward displacement of the shoulder and the abnormal prominence of the outer end of the clavicle which slightly overlaps the acromion. Further displacement is prevented by the coraco-clavicular ligaments which remain intact.

In the downward type of luxation the outer end of the bone lies below the acromion and is displaced backward. The middle third of the shaft is less prominent than normal, the trunk is inclined to the injured side and the shoulder is lowered. The downward displacement of the outer end causes the sternal extremity to become unduly prominent. The entire inner border of the acromion is palpable and the articular facet may be felt. It will usually be possible to feel the clavicle at the point where it passes under the acromion.

In the subcoracoid form the clavicle is said to be lodged under the coracoid process. The outer end of the bone lies in the axilla and there is great ecchymosis in the region of the coracoid.

Diagnosis.—In the usual type of acromio-clavicular luxation the diagnosis may be tentatively made by inspection alone. The nature and position of the prominence is characteristic. Manipulation of the clavicle or shoulder causes motion at the acromio-clavicular joint. The region of the prominence should be carefully palpated to exclude fracture of the outer end of the clavicle, and fracture of the acromion. Either of these conditions is productive of crepitus. The ligaments sometimes avulse a small portion of either clavicle or acromion in lieu of rupture of the ligament itself, and when this occurs the surgeon may be able to elicit crepitus and mistake the condition for fracture. Careful palpation, however, will determine the false motion in the joint itself and not to the outer or inner side of it. The displaced axis of the clavicle and the relatively raised acromion should suggest the condition in the rare downward type.

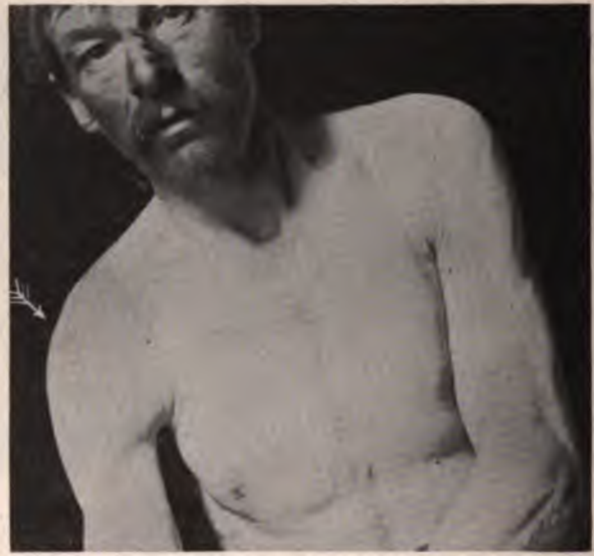

Fig. 43.—Downward dislocation of the outer end of the clavicle. The outer end of the clavicle is caught under the acromion and the patient assumes this attitude as the one of least discomfort.

Treatment.—In the common type of luxation reduction is, as a rule, easily effected by upward, outward and backward traction on the shoulder. Recurrence of deformity, however, is the rule and retentive dressing should be at hand to maintain the outer end of the clavicle in position as soon as reduction is accomplished. Stimson's adhesive plaster dressing is quite satisfactory in preventing redisplacement. The axilla is first cleansed, sponged with alcohol, and dried and a folded towel is placed between the arm and the chest to prevent skin coming in contact with skin during the subsequent immobilization. The arm is then placed at the side and the elbow semiflexed. A strip of adhesive four feet long and three or four inches wide is then placed under the elbow. One end is carried up the anterior aspect of the arm and over the shoulder at the site of luxation. The posterior end of the plaster is carried up the posterior aspect of the arm in a similar manner and carried forward over the shoulder. As the ends of this dressing are being brought into position the shoulder should be raised upward, backward and outward, and pressure should be made on the outer end of the clavicle. When the plaster is properly placed it pulls upward on the semiflexed elbow and exerts downward pressure on the outer third of the clavicle. The arm is then secured to the side by means of a body swathe and the forearm carried in a sling.

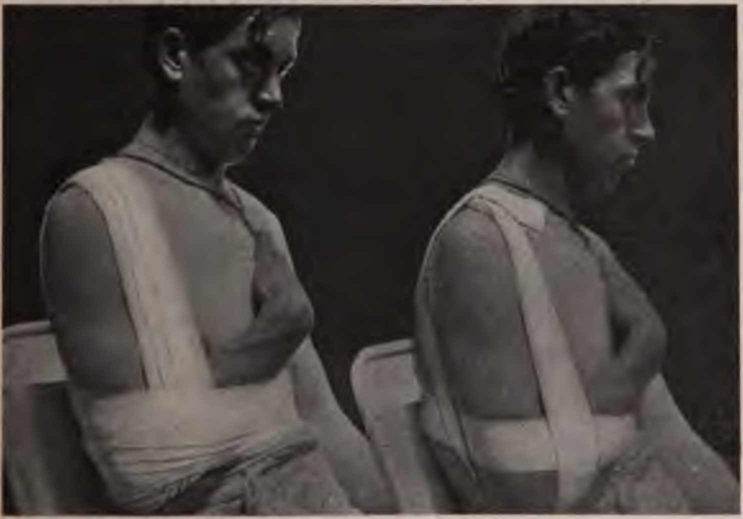

Fig. 44. Fig. 45.

Fig. 44.—Dressing to maintain reduction in luxation of the outer end of clavicle.

Fig. 45.—Same principle carried out with adhesive plaster instead of bandage. Note the pad over outer end of clavicle.

In the downward type of luxation reduction is accomplished by outward traction on the shoulder and direct manipulation of the clavicle by grasping it in its middle third. Recurrence of deformity does not, as a rule, occur following reduction, and accordingly no retentive apparatus other than a sling and body swathe will be needed.

Operative Treatment.—Open treatment is seldom indicated since reduction can, as a rule, be maintained by the dressings just described. In exceptional instances suture of the outer end of the clavicle to the acromion may be needed to prevent recurrence of deformity. Both wire and absorbable suture material have been successfully employed. It may be possible in some cases to suture the ligaments about the end of the bone in such a manner as to obviate the necessity of drilling into the bone. In the downward variety of luxation operation may be called for to disengage the outer end of the clavicle.

After-Treatment.—The clavicle should be watched for recurrence of deformity especially following the upward type of luxation. A certain amount of slipping will take place in the dressings and should be corrected to keep the end of the bone in position. Irritation may develop at the site of pressure and require attention. Three to four weeks should be allowed for the ligaments to heal.

Prognosis.—The outlook in the ordinary case of luxation of the outer end of the clavicle is good as far as restoration of function is concerned. The prominence of the articulation may be a little greater than normal when recovery is complete, and in some cases a slight amount of displacement may persist, but these conditions are not incompatible with free use of the part and a strong joint. Downward luxations may be attended by injury to the brachial plexus since this displacement decreases the space between the clavicle and the first rib, and the prognosis will depend on the severity of the plexus involvement. Old unreduced luxations often show a remarkable restoration of function and the formation of a new joint.

CHAPTER V.

FRACTURES OF THE SCAPULA.

Surgical Anatomy.—The freedom of motion in this bone and the fact that it is almost entirely surrounded by heavy muscles, account for the rarity with which it is fractured. Some portions of the scapula (spine and acromion process) are subcutaneous and accordingly more often injured. The acromial epiphysis usually joins the remainder of the bone between the eighteenth and twenty-fifth years, although it may remain ununited throughout life. This condition has been mistaken for fracture. The attachments of the deltoid and trapezius tend to prevent displacement when this portion of the bone is broken. The attachment of these muscles and the heavy fibrous tissue surrounding the acromion and spine explain the difficulty of eliciting crepitus in the presence of fracture in this region. When, however, these structures are lacerated

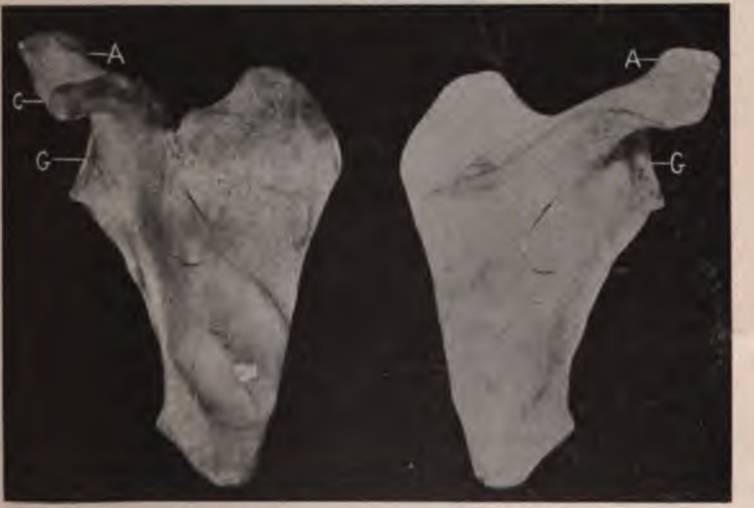

Fig. 46. Fig. 47.

Figs. 46 and 47.—Ventral and dorsal surfaces of the right clavicle. *A.*, Acromion process; *C.*, Coracoid process; *G.*, Glenoid cavity.

sufficiently to allow displacement, crepitus, abnormal mobility and deformity are recognized without difficulty. If the fracture is internal to the acromio-clavicular articulation we have a condition closely resembling dislocation of the outer end of the clavicle.

Fracture of the coracoid is an extremely rare occurrence. It has been broken as the result of muscular action due to the pull of the short head of the biceps, coraco-brachialis and pectoralis minor. Epiphyseal separation of this process has been known to occur prior to the seventeenth year, at which time ossification makes it continuous with the rest of the bone.

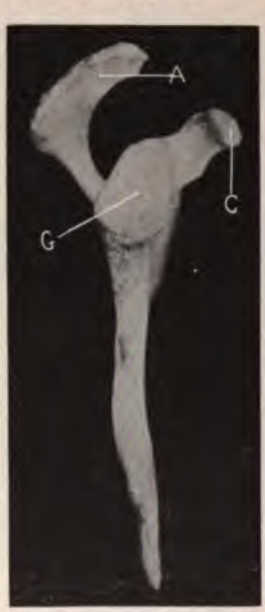

Fig. 48.—View of the same bone from the axillary border. Note the relation of the coracoid and acromial processes to the glenoid cavity.

Fracture of the glenoid cavity usually results from violence transmitted through the head of the humerus. It may exist as a complication of fracture or dislocation of the humeral head. Fracture of the neck of the scapula may occur from similar causes. The thinnest and best protected portion of the bone is *the body*. Fracture rarely occurs in this region, but when it does it is almost invariably the result of direct violence. The spring of the ribs supporting the scapula undoubtedly enables it to withstand greater violence, but when trauma is severe we may have fracture of the underlying ribs as well as of the body of the bone. When such is the case, the more superficial fracture may conceal the injury to the ribs. *Fracture of the body* is usually transverse below the spine. Comminution is sometimes observed and in rare instances the line of fracture may cross the spine. The attachments of the infraspinatus, subscapularis, serratus magnus, rhomboid and teres muscles are such that pronounced displacement rarely occurs and palpation is difficult.

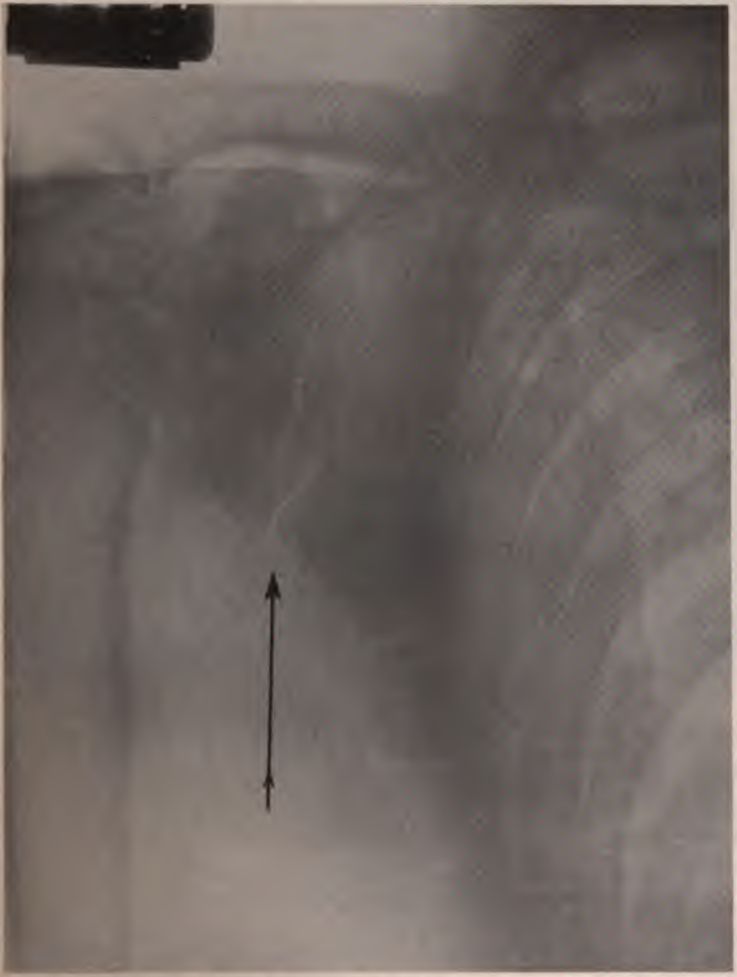

Fig. 49.—Fracture of the neck of the scapula.

Symptoms.—Loss of function, and pain (which is increased on motion) are always present. Deep respiration causes suffering, though the rapid shallow breathing, characteristic of fractures of the ribs, is absent. *The body of the scapula* may be grasped as shown in Fig. 50 when abnormal mobility and crepitus are elicited, completing the list of symptoms.

Fracture of the acromion process produces localized pain, tenderness, and sometimes limited mobility and crepitus. The symptoms vary with the position of the fracture in relation to the acromio-clavicular articulation. Fracture of the acromion, external to the acromio-clavicular joint, produces local pain and tenderness. Crepitus and abnormal mobility may be present on manipulation, but deformity is almost uniformly absent. Fracture of the acromion entering the articulation gives rise to symptoms closely resembling fracture external to the joint, though motions of the shoulder are usually more painful. Fracture of the acromion internal to its articulation with the clavicle, is accompanied by symptoms almost identical with dislocation of the outer end of the clavicle, especially if the muscular and fibrous attachments of the process have been torn sufficiently to allow deformity. The shoulder drops downward, forward and inward, and undue prominence is observed at the outer end of the clavicle. Palpation reveals the acromial fragment attached to the outer end of the collar bone. Abnormal mobility of the displaced acromial fragment is present, but crepitus is absent unless the fractured surfaces have remained in contact.

Fracture of the coracoid gives rise to localized pain and tenderness just below the junction of the middle and outer thirds of the clavicle. Displacement, if present, is very slight owing to the fact that the rhomboid and trapezoid ligaments are seldom torn. These ligaments securely hold the fragment in position against the actions of the attached muscles. The tip of the coracoid may be palpated if pressure is made at the proper point below the clavicle. It is impossible, however, to grasp the process between the fingers, and for this reason it is difficult to elicit crepitus and abnormal mobility.

Fracture of the surgical neck of the scapula gives a picture somewhat resembling dislocation of the shoulder, although the deformity is not characteristic of any type of shoulder luxation, and crepitus can usually be elicited by manipulation. Fracture of the glenoid cavity, especially a fragment from the anterior edge, is a complication sometimes occurring in dislocations of the shoulder, and results in spontaneous recurrence of deformity following reduction. Crepitus may, or may not, be present.

Diagnosis.—A consideration of the symptoms occurring in fractures of different regions of the scapula should render the diagnosis in most cases easy. Fracture of the acromion and body are by far the most common injuries seen in this bone. Fracture of the surgical neck may, at times, be extremely difficult to differentiate from dislocations of the shoulder and fractures of the upper end of the humerus. Deep palpation of the axilla may detect the glenoid cavity moving with the head in its inward displacement. Fractures of the glenoid cavity, surgical neck and coracoid, may require the use of the X-ray before diagnosis can be established. The frequency with which radiography reveals unsuspected conditions in and about the shoulder demonstrates the value of the X-ray as a routine measure in injuries of this region. The difficulty of diagnosis is greatly increased if the case is not seen for twenty-four or forty-eight hours following the accident. By this time the swelling and tenderness have so increased that less is learned from inspection or palpation, and manipulation of the parts is seriously objected to by the patient. An anesthetic is often neces-

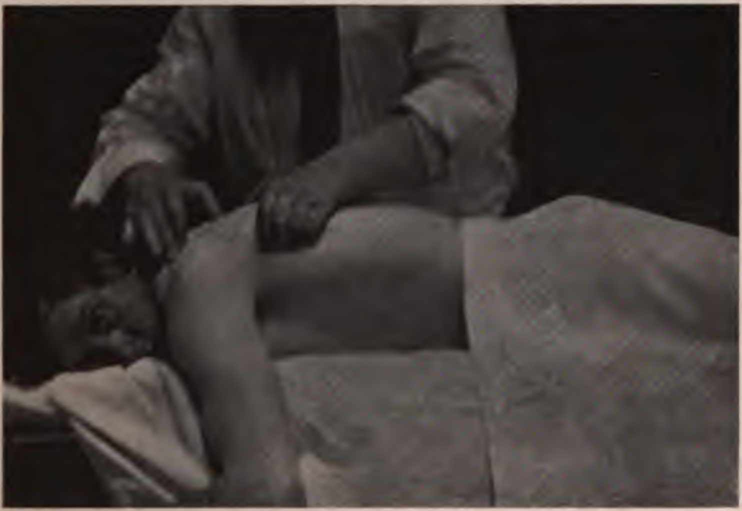

Fig. 50.—Method of grasping the body of the scapula to detect the presence of fracture. The fingers of the right hand are palpating the spine of the scapula.

sary to determine the condition, especially if the X-ray is not available.

Treatment.—The treatment must, of necessity, vary with the region and function of the portion of the bone injured. Fracture of the body of the bone calls for strapping of the chest in such a manner that the scapula will be immobilized. In addition the arm should be fixed to the side of the chest by a swathe or additional strapping. The Velpeau bandage may be used to advantage, especially when reinforced with starch or plaster of Paris. Opposing surfaces of skin should be protected by the interposition of some absorbent material, such as cotton. In fracture of the acromial process, especially with displacement, the indications in treatment are similar to those of fracture of the clavicle. A Sayre's dressing, or modification, such as shown on page 24, will answer the purpose satisfactorily. Additional pressure directly over the fragment may be had by means of a strap of adhesive and pad of gauze appropriately placed. In fracture of the coracoid process direct immobilization of the fragment is hardly possible, yet the arm should be so fixed to the side as to prevent action of the three muscles attached to the process. The indications in the treatment of fractures of the surgical neck of the scapula are similar to those of fracture of the upper end of the humerus. The axillary pad and plaster of Paris shoulder cap can, as a rule, be so applied that the fragment is held in proper reduction. (See Figs. 132 to 140.) It is

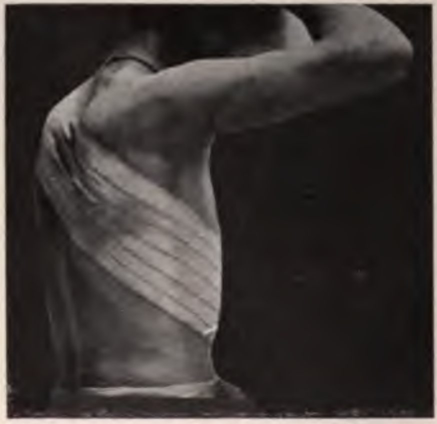

Fig. 51.—Oblique strapping with adhesive plaster to immobilize the body of the scapula.

usually unwise to allow use of the forearm or hand in fractures of any portion of the scapula. In the less severe conditions the arm should at least be carried in a sling, while the remainder of the upper extremity is securely immobilized.

After-Treatment.—Union will usually take place within a month. When fracture occurs in parts of the scapula which are subject to considerable strain, such as the neck of the bone or the acromion, internal to its articulation with the clavicle, immobilization should be maintained for about two weeks longer. The dressings should be carefully inspected daily for the first week to avoid loosening and slipping. If irritation of the skin occurs it should receive proper attention.

Prognosis.—Fractures of the body of the scapula seldom produce permanent impairment of function. Fractures of the surgical neck, and of the acromion with displacement, may be followed by some loss of function, if not properly reduced. Perfect function is likely to follow fibrous union of the coracoid.

CHAPTER VI.

DISLOCATIONS OF THE SHOULDER.

Surgical Anatomy.—The peculiar construction of the shoulder joint, its wide range of motion and exposed position, result in its being the most common site of dislocation in the body.

The articulation is typical of the ball and socket joint. The bones entering into its formation are the head of the humerus and the glenoid cavity of the scapula. The acromion and coracoid processes, with the coraco-acromial ligament stretching between them, are not considered a part of the joint proper, yet they play an important part in preventing upward displacement of the humeral head. The wide range of motion possible in this joint is the result of the disproportion in the sizes of the articular surfaces of the humeral head and glenoid cavity. Extreme mobility renders the upper extremity more serviceable in many ways, but on the other hand it is evident that this type of joint construction is dependent almost entirely on ligaments and muscles for its stability. The coraco-acromial and capsular are the only ligaments of surgical importance in the shoulder joint. The coraco-acromial ligament arches over the head of the humerus, filling in the space between the two processes and serves to prevent upward displacement of the humerus. The capsular ligament entirely surrounds the articulation, being attached to the rim of the glenoid cavity just beyond the glenoid ligament, and externally to the anatomical neck of the humerus. This ligament is much too lax on all sides to keep the articular surfaces in contact, but this very laxity is necessary to allow the freedom of motion which this joint enjoys. A portion of the capsule becomes taut only when the arm is carried to the extreme limit of motion in a given direction. (See Figs. [illegible] and [illegible].) Some portions of the capsule are more subject to strain than others, and accordingly we find such parts reinforced by muscle tendons or thickenings in the capsule itself. These thickenings have been given special names, such as the coraco-humeral in the upper part of the joint, and the ligaments of Flood and Schlemm anteriorly. The transverse humeral ligament serves to confine the long tendon of the biceps within the bicipital groove, and the glenoid ligament forms a margin around the glenoid cavity, increasing its depth. The ligaments surrounding the joint prevent dislocation by limiting the range of motion, while the muscles, by their tonicity, actively hold the articular surfaces in apposition. The deltoid arising from the clavicle, acromion and spine of the scapula keeps the humerus well up in place against the under surface of the arch made by the coracoid, coraco-acromial ligament and acromion. Paralysis of this muscle results in a dropping of the humerus with separation of the articular surfaces in the shoulder joint. The tendon of the long head of the biceps strengthens the upper part of the capsule, keeps the head of the humerus in proper apposition with the glenoid during the various movements of the arm and prevents the head from being pulled too closely upward under the acromion. The action of the coraco-brachialis is similar to that of the deltoid in holding the humerus up. The tendon of the subscapularis reinforces the capsule, and in the anterior dislocations is not infrequently torn when this particular portion of the capsule is penetrated by the head. The tendons of the supraspinatus, infraspinatus and teres minor reinforce the capsule and aid in maintaining the proper relations of

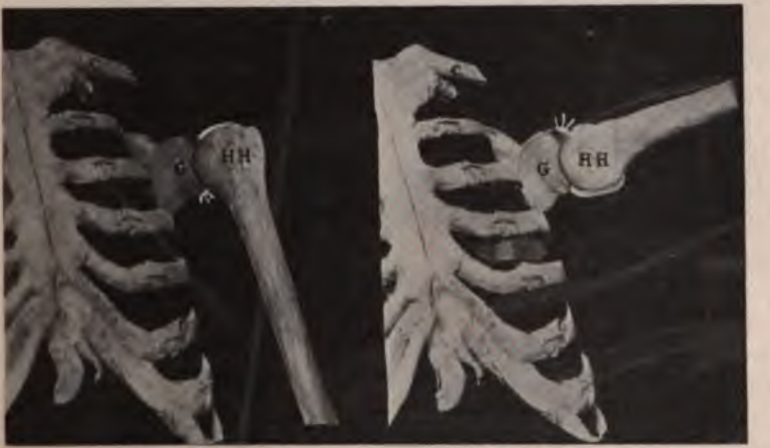

Fig. 52. Fig. 53.

Figs. 52 and 53.—Diagrams illustrating the action of the capsule in different positions of the joint. It is apparent that it must be lax enough on all sides to allow motion of the humerus in different directions and that its function is to limit motion and not to hold the humeral head firmly against the glenoid cavity.

the articular surfaces. The brachial plexus and axillary artery occupy a position internal to the head as they descend through the axilla, and may be injured in dislocations of the shoulder. In the forward and downward types of luxation direct pressure may be made on these structures by the humeral head; the pulsating axillary artery may often be palpated as it stretches across the head in subglenoid luxations. The injuries sustained by the structures about the joint depend on the direction taken by the head as it leaves the glenoid and the degree of violence producing the luxation. The planes of least resistance about the joint lie between the muscles rather than through them, though naturally the greater the violence producing the dislocation the greater the probability of a muscle being penetrated by the head. The subscapularis is the muscle most frequently penetrated in this manner.

The capsular ligament is practically always torn at the point where the head leaves the glenoid fossa and, since the common displacements are of the anterior variety, the rent will usually be found in the antero-inferior portion of the capsule. A few cases of anterior luxation without injury to the capsule have been reported in which the joint was previously much relaxed and the capsule unusually roomy. Injury to the capsule is not infrequently accompanied by injury to the tendons which overlie and reënforce it and, when the violence producing the luxation is great, there may be a destruction of tendon continuity.

The trauma causing the luxation may at the same time produce a fracture of the glenoid cavity or of the upper end of the humerus. The anterior rim of the glenoid may be broken off by the head of the humerus as the articular surfaces are forced past each other. The head and tuberosities may suffer a variety of fractures which are so diverse that two cases are rarely seen alike. The greater tuberosity is sometimes found parted from the shaft and displaced in the line of the pull of the muscles attached to it. This fragment may lie in the glenoid cavity where it offers obstruction to reduction. Fractures of the surgical neck, with or without dislocation of the shoulder, are more constant in type than fractures of the anatomical neck. Fracture of the anatomical neck, especially when complicated by dislocation, is sometimes represented by a comminuted, crushed condition of the upper end of the humerus, in which the lines of fracture are extremely variable. The cap of bone represented by the articular surface is usually less comminuted than either the underlying structure or the tuberosities.

Fracture of the upper end of the humerus more often occurs in those cases of dislocation which have been produced by direct violence, the blow having been sustained on the outer side of the shoulder just below the acromion.

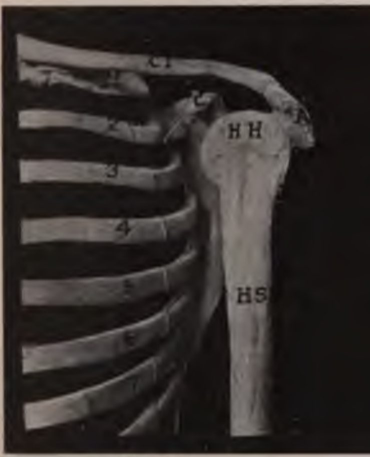

Fig. 54.

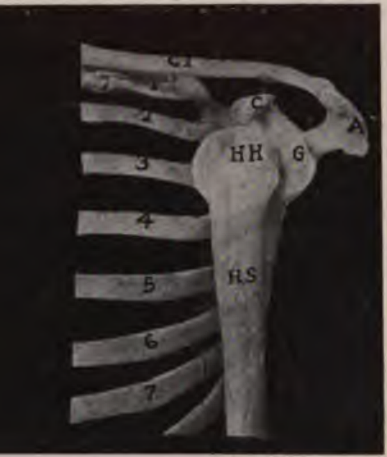

Fig. 55.

Fig. 54.—Normal shoulder. *Cl.*, clavicle; *C.*, coracoid process; *A.*, acromion process; *G.*, glenoid cavity; *H.H.*, humeral head; *H.S.*, humeral shaft.

Fig. 55.—Subcoracoid dislocation.

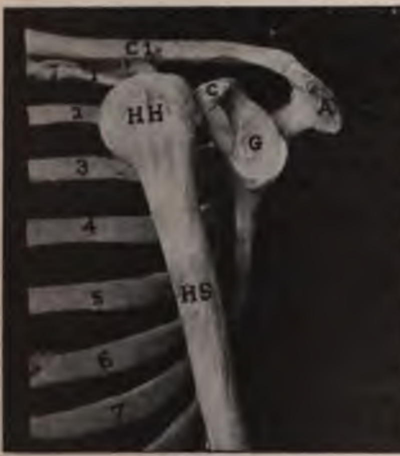

Fig. 56.

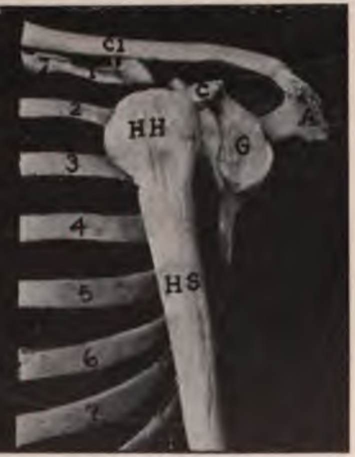

Fig. 57.

Fig. 56.—Intracoracoid or subclavicular dislocation. *Cl.*, clavicle; *C.*, coracoid process; *A.*, acromion process; *G.*, glenoid cavity; *H.H.*, humeral head; *H.S.*, humeral shaft.

Fig. 57.—Intraclavicular dislocation with moderate deformity.

Separation of the lesser tuberosity has been noted as a complication of dislocation of the shoulder, though it is much rarer than fracture of the necks or greater tuberosity.

The most important structures which may be injured by the

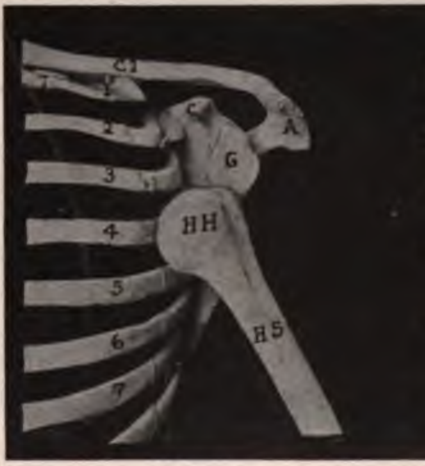

Fig. 58.

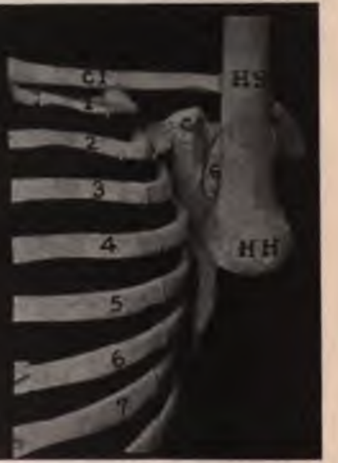

Fig. 59.

Fig. 58.—Subglenoid dislocation. *Cl.*, clavicle; *C.*, coracoid process; *A.*, acromion process; *G.*, glenoid cavity; *H.H.*, humeral head; *H.S.*, humeral shaft.

Fig. 59.—Luxatio erecta. A variation of the subglenoid type.

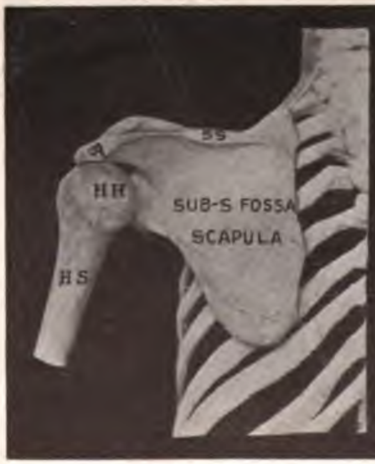

Fig. 60.

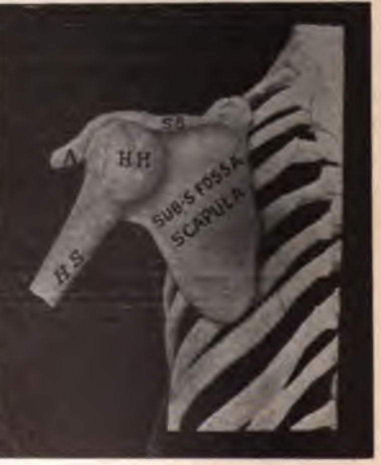

Fig. 61.

Fig. 60.—Subacromial dislocation. The less pronounced of the two posterior luxations. *H.H.*, humeral head; *H.S.*, humeral shaft; *A.*, acromion process; *S.S.*, spine of scapula.

Fig. 61.—Subspinous dislocation. An exaggeration of the subacromial type.

displaced head are the brachial plexus and axillary artery which lie just internal to it in the axilla. When the artery is torn hemorrhage into the axilla will follow, while simple pressure on the vessel will only temporarily interfere with the pulse in the arm below. Pressure on the brachial plexus may result in partial or complete paralysis of the parts supplied by it. The exact mechanism of injury to the brachial plexus is not thoroughly understood; some writers consider it a result of direct pressure on the nerves by the head or neck of the bone, while others are of the opinion that the stretching sustained by the plexus is the usual method of injury. In any case this complication is fortunately rare, and the resulting paralysis usually transient. There is little doubt that the plexus may be injured in attempts at reduction, especially when the older method of using a fulcrum in the axilla is resorted to. Permanent injury to the artery is seldom seen; as a rule we may look for nothing more than a temporary suspension of circulation below the point of pressure, during the time the head is out. When the dislocation is allowed to remain unreduced for a few weeks fibrous tissue is formed about the head, which will ultimately make a new socket, and in many instances we see remarkable restoration of function. The usefulness of the joint, however, can never be expected to approach the normal under such circumstances.

The head of the humerus may pass from the glenoid in almost any direction, and this fact has given rise to a variety of classifications which in many instances have but served to confuse rather than help us to a clearer understanding of the subject. The simplest classification will be used here:

Forward	Subcoracoid Subclavicular (or intracoracoid)
Downward	Subglenoid Subglenoid erect (Luxatio erecta)
Backward	Subacromial Subspinous
Upward	(very rare)

By far the most frequent dislocation of the shoulder is forward, and of the two subvarieties the subcoracoid is much more common. The subglenoid is next in order of frequency, while the erect type is more uncommon than either of the posterior varieties.

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In the *subcoracoid type* the head lies below the coracoid process, having escaped through the antero-inferior portion of the capsule. The line to be drawn between this luxation and the subclavicular variety is purely artificial and arbitrary. If more than three-fourths of the transverse diameter of the humeral head lie internal to the coracoid the luxation is known as subclavicular. More or less inward rotation of the humerus is present. The tendon of the subscapularis is not infrequently torn, and in rare instances injury may be sustained by the supraspinatus, infraspinatus or teres muscles. Tearing of the coraco-humeral ligaments practically never occurs in this type of luxation. The head of the bone often lies on the anterior edge of the glenoid cavity.

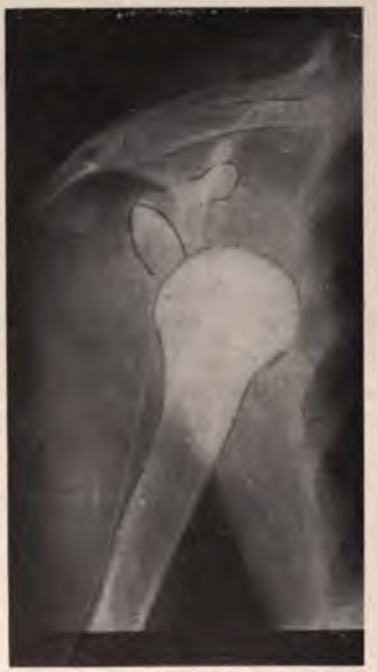


Fig. 62.—Outlined X-ray of a low subcoracoid dislocation of shoulder.

In the *subclavicular type* the head continues inward, clears the coracoid process and rises to a slightly higher level. The tearing of the capsular ligament is usually more severe than in the subcoracoid form and rupture of the tendons inserted into the upper end of the humerus is more common. The coraco-humeral ligament is often extensively torn and accordingly Kocher's method of reduction will fail.

Subglenoid luxations.—In the typical subglenoid dislocation the head of the bone lies below the glenoid cavity. There is no hard and fast line to be drawn between the subcoracoid and subglenoid varieties, since in practice we find the head may occupy a position anywhere along the anterior rim of the glenoid cavity.

In the *erect type of subglenoid luxation* (luxatio erecta) the head lies below the glenoid but the arm is in a position of extreme abduction.

In the *subacromial type* the head of the bone lies behind the glenoid cavity just under cover of the acromion. The rent is in the posterior portion of the capsule. The biceps tendon may be torn out of its groove and the bellies or tendons of the muscles inserted into the greater tuberosity (especially the infraspinatus) may be extensively torn. Complicating fracture of the greater tuberosity is more common in this type of luxation than in the subcoracoid form. The tendon of the subscapularis may be torn from its insertion into the lesser tuberosity.

The *subspinous* form is an exaggeration of the subacromial, in which the head continues in its backward course till it lies in the infraspinous fossa just below the spine of the scapula. The violence producing this form is great and it is usually only a short time following the accident until the surrounding tissues and skin covering the head are filled with ecchymotic blood. Injury to surrounding muscles and ligaments is usually more extensive than in the subacromial type.

The *upward variety* is only possible when the acromion has been fractured, and is so extremely rare that it might better be considered a surgical curiosity.

There is no hard and fast line to be drawn between the subcoracoid and subglenoid varieties since in practice we find the humeral head may occupy positions at different levels anywhere along the anterior rim of the glenoid cavity. This fact is demonstrated by the accompanying photographs and Röntgenograms. In like manner the subcoracoid luxation merges into the subclavicular type.

Etiology.—This is the most common dislocation in the entire body. It occurs most frequently in adult life and results from various types of trauma applied to the shoulder. The most common form of luxation is usually produced by violence applied to the shoulder when the arm is in extreme abduction.

Symptoms.—Immediately following the accident the patient suffers severe, acute, nauseating pain which is increased by motion of the affected shoulder. Loss of function is produced by the inhibitory effect of pain, by the reflex spasm of the muscles and by the mechanical disturbance in the joint. If the luxation is allowed to go uncorrected the first two conditions grow gradually less while the last named persists and results in permanent disability. The nature of the deformity will depend on the type of luxation.

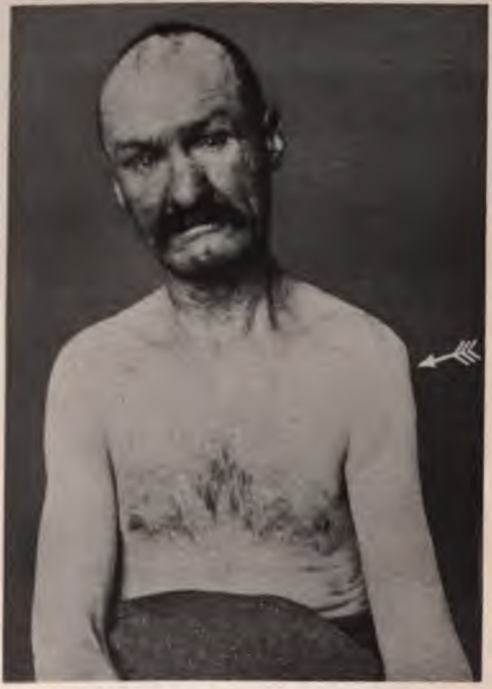


Fig. 63.—Recent subcoracoid dislocation of left shoulder. Note the flattened shoulder as indicated by the arrow, the change in the axis of the humerus and the lowering of the axillary fold. This picture is quite typical of the subcoracoid form of luxation. It will be noted that the patient makes no attempt to support the injured member as is commonly done in fractures of the clavicle or humerus, especially the latter.

In the *subcoracoid variety* there is a flattening of the shoulder which when palpated, as shown in Fig. 65, allows the examining fingers to pass inward under the acromion process. The upper end of the humerus is displaced inward and the axis of the arm

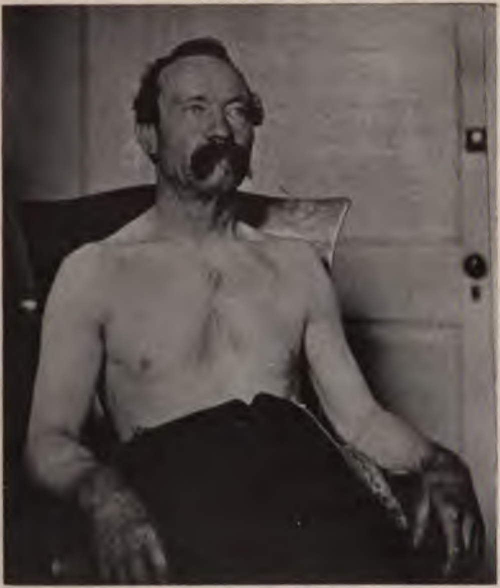


Fig. 64.—Simple subcoracoid dislocation of left shoulder presenting the usual symptoms: flattening of the shoulder, change in axis of arm and lowering of the axillary fold.

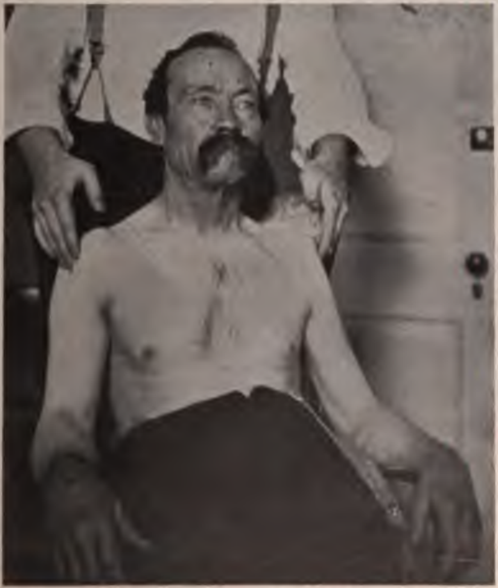


Fig. 65.—Examining depression below the shoulder. Note how, with moderate pressure, the fingers sink in below the acromion. Photograph taken just after the accident and immediately prior to reduction by Kocher's method.

is altered. This change in the axis of the humerus may be recognized at a glance. The humeral head rests beneath the tip of the coracoid process and occupies a slightly lower position than normal. Lowering of the humerus as a whole lowers the attachment of the pectoralis major and accordingly the anterior axillary fold will be lower on the injured side. An abnormal prominence will be noted below the coracoid where the head has found its new resting place. The elbow seldom lies in contact with the side of the chest and any attempt at adduction will meet with resistance and cause additional pain. Abduction will bring out the lines of the already prominent acromion, accentuate the flattening of the shoulder and is not specially productive of resistance and pain. It is difficult to place the hand of the injured side on the opposite shoulder and when this has been accomplished it will be found impossible to keep the elbow in contact with the chest. This symptom is characteristic of anterior luxations and is the result of the head being "off center." A simple though unnecessary test is to place a ruler on the outer side of the arm; it will be noted that the ruler can be placed in contact with the acromion and external epicondyle simul-

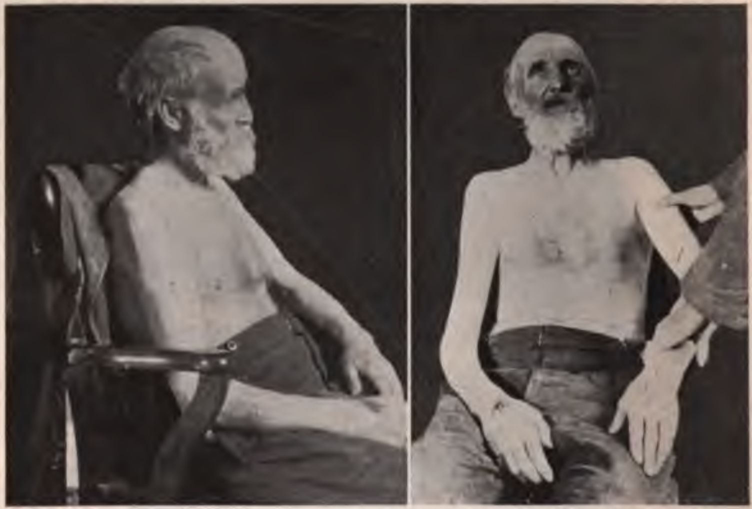


Fig. 66. Fig. 67.

Figs. 66 and 67.—Lateral and anterior views of a subcoracoid luxation of right shoulder. This shoulder has been dislocated eight times, the first luxation being about ten years ago. The manner in which the fibres of the deltoid pass in straight lines from the acromion to their insertion indicates the absence of the head of the humerus from the glenoid cavity. Reduction accomplished by Kocher's method with the patient in the sitting position.

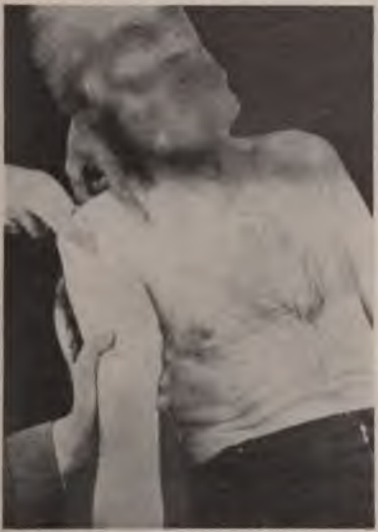


Fig. 68.—Another view of the same case showing the position of the humeral head as indicated by palpation. The head lies between the two fingers on the shoulder.

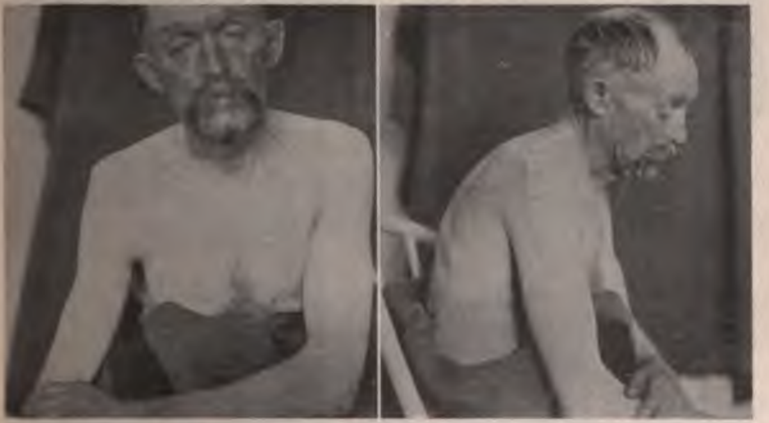


Fig. 69. Fig. 70.

Figs. 69 and 70.—Another subcoracoid dislocation of the shoulder presenting the usual symptoms. In this case the head of the humerus occupies a slightly lower position than seen in the cases shown on the preceding pages. The slight deltoid angle present is the result of this lower position of the head. The change in the humeral axis, flattening of the shoulder, lowering of the axillary fold and "deltoid angle" are all more pronounced than seen in the typical subcoracoid luxation. This is due to fact that the head of the bone is lower and the dislocation assumes slightly the characteristics of the subglenoid type.

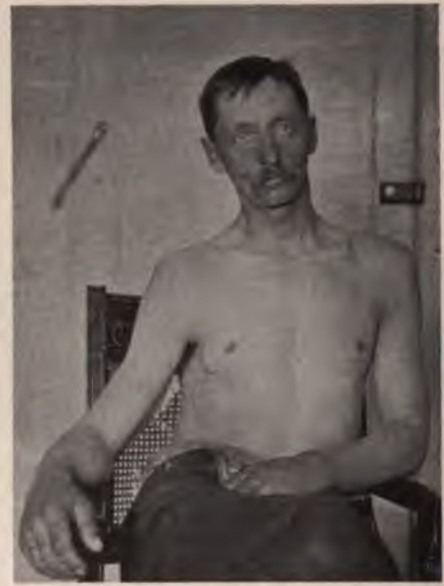


Fig. 71.—An anterior dislocation of the shoulder about half-way between the subcoracoid and subglenoid types. Compare this case with those shown in Figs. 63, 64, 67, 75 and 77.

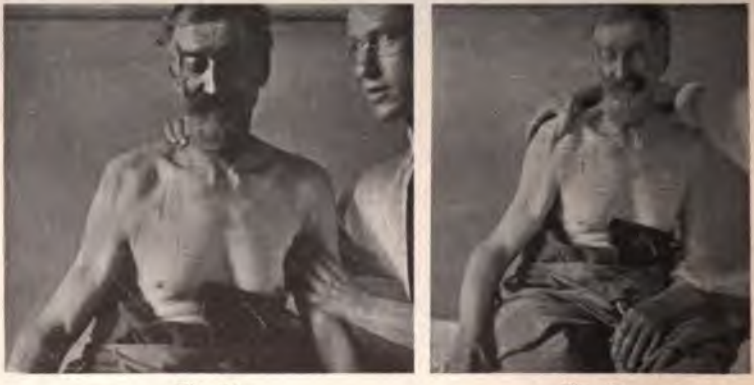


Fig. 72. Fig. 73.

Figs. 72 and 73.—Anterior dislocation of the right shoulder with the head occupying a slightly lower position than that seen in the preceding case (Fig. 71). This case might properly be termed a high subglenoid luxation. The empty glenoid is well indicated by the straight lines of the deltoid muscle and the prominence of the coracoid process with its attached muscles. The thumb pressed into the shoulder lies directly above the displaced head. Note how closely this case resembles the typical subglenoid luxation shown in Fig. 77.

taneously, which is impossible in the normal shoulder. The head of the bone may be palpated in its new position in the axilla. Slight abduction of the arm facilitates this portion of the examination. The head may also be palpated through the deltoid and pectoralis major as shown in Fig. 68.

The patient's attitude is characteristic. In standing the body is inclined slightly forward and toward the injured side. This position is assumed so the displaced humeral axis may be brought more nearly to the vertical. There is very seldom any attempt made to support the injured member but instead it hangs limp from the shoulder. In the sitting position the arm is rested on some convenient object such as a table, or the arm of a chair. In the typical subcoracoid luxation the elbow is close to, but not in contact with, the side. When the head occupies a lower position on the anterior rim of the glenoid abduction of the arm will be more pronounced.

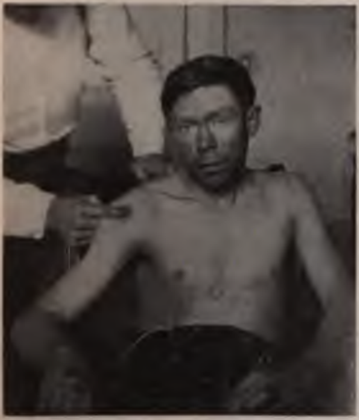


Fig. 74.

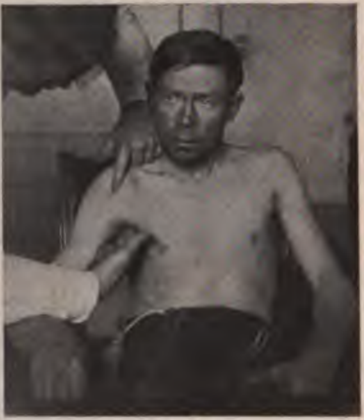


Fig. 75.

Fig. 74.—Subglenoid dislocation of right shoulder. The head of the humerus lies below the palpating finger. While plowing the share struck a rock and the handles of the implement were thrown violently upward and the right shoulder dislocated.

Fig. 75.—Same case. The head of the humerus lies between the two index fingers. The brachial plexus and pulsating axillary artery can be felt stretched across the head by the fingers palpating in the axilla.

In the *subclavicular or intracoracoid* type the shoulder is flatter and the prominence below the clavicle, caused by the head, is nearer the median line. After the head clears the coracoid in its inward course it rises to a higher level, and thus the whole humerus occupies a higher position than that seen in the subcoracoid type.

The level of the anterior axillary fold is variable. The deformity depends somewhat on the completeness of rupture of the coraco-humeral ligament. If this ligament is completely ruptured the arm is usually closely applied to the chest wall. If it is only partially ruptured abduction of the arm may be pronounced even to the extent of being held in a nearly horizontal position. It may be possible to palpate the empty glenoid cavity. The arm usually shows more or less shortening which is accentuated by abduction. When the coraco-humeral ligament is completely ruptured the head may occupy an unusually low position beneath the clavicle.

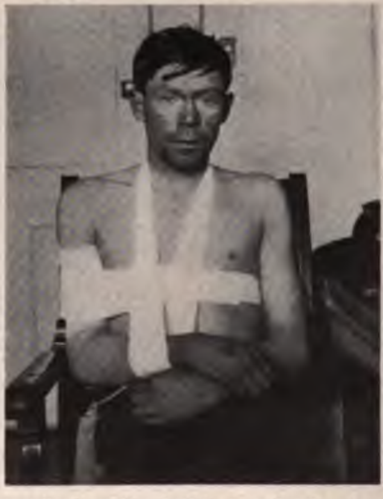


Fig. 76.—Same case after luxation had been reduced. Arm bandaged and fixed to side by strip of adhesive encircling the chest.

In the *subglenoid variety* the humeral head rests on the long head of the triceps below the glenoid cavity, though this position is occupied only in the most pronounced cases. All the symptoms noted in the subcoracoid type are present in exaggerated form in the subglenoid variety. The arm is lengthened, the axillary fold much lowered, the axis of the humerus pronouncedly altered and abduction of the arm is a prominent symptom. The lowering of the humerus is greater in this form than in any other type of luxation occurring at the shoulder joint. The outer side of the arm forms an angle ("deltoid angle") with the insertion of the deltoid as the apex. This angle is the result of abduction and indicates the low position of the head.

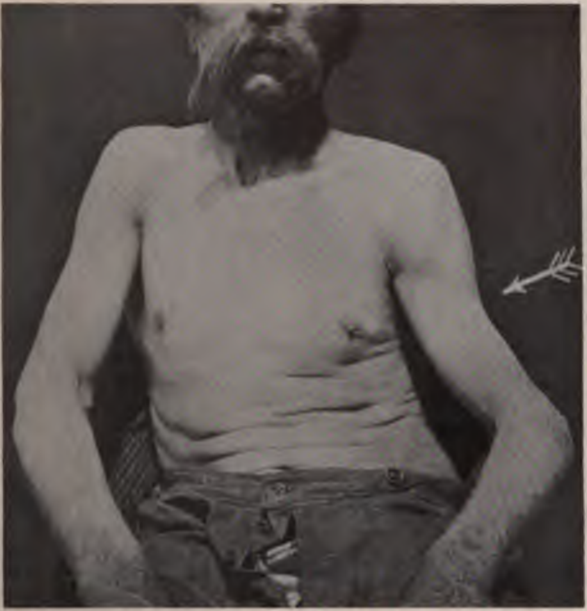


Fig. 77.—A typical subglenoid dislocation of the left shoulder. Flattening of the shoulder, lowering of the axillary fold and change in the humeral axis are much more pronounced than in the subcoracoid type. In the subcoracoid type the outer surface of the arm is approximately a straight line but in this case it will be noted that a distinct angle is formed which for convenience has been termed the "deltoid angle." The apex of the angle is indicated by the arrow. The upper arm of the angle extends to the acromion while the lower arm extends to the external epicondyle. The lower the position occupied by the luxated head the more pronounced will this angle be.

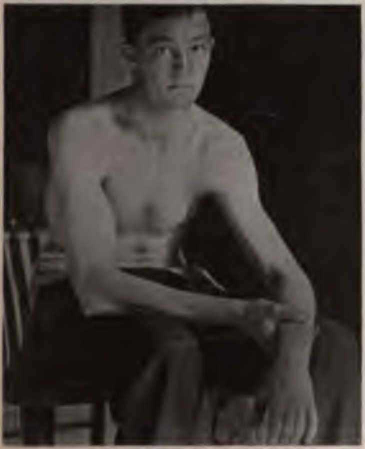


Fig. 78.

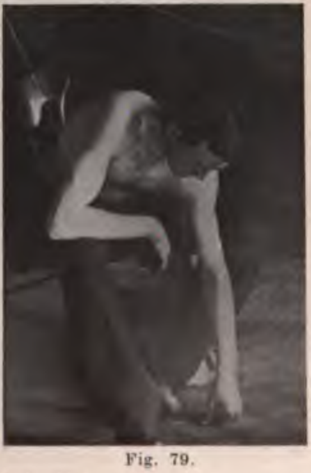


Fig. 79.

Fig. 78.—Typical subglenoid dislocation of left shoulder.

Fig. 79.—Attitude assumed by patient since it is accompanied by less pain than any other position. This attitude is not especially uncommon in subglenoid luxations.

Compare the clinical appearance of the cases shown in the accompanying illustrations. Fig. 77 shows a typical subglenoid luxation. Fig. 72 shows a higher form while Fig. 69 shows what might be termed a low subcoracoid.

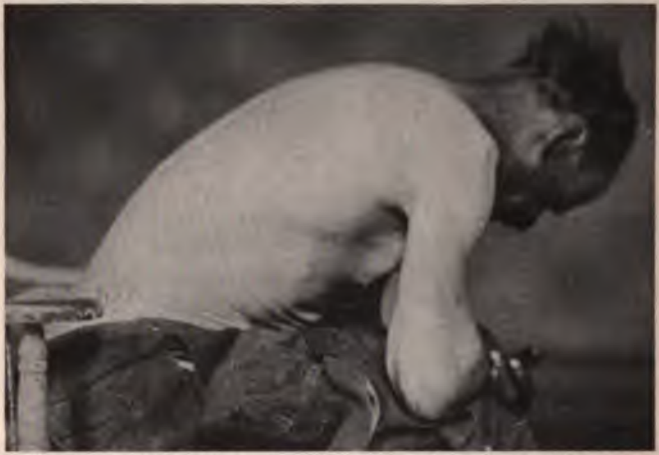


Fig. 80.—Subglenoid luxation. Attitude of least discomfort similar to one seen in Fig. 79.

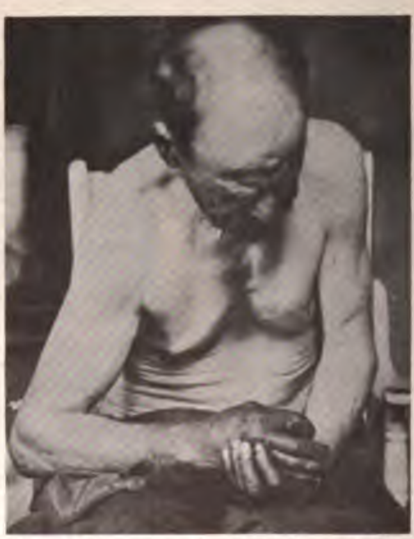


Fig. 81.—Another view of patient shown in Fig. 80.

In the *erect type of subglenoid luxation* (luxatio erecta) the shoulder is dislocated while the arm is in extreme abduction and the head comes to rest at the lowest possible point, being in some cases even caught under the long head of the triceps. The attitude is characteristic; the arm is raised and the hand usually rests on the top of the head. The patient is unable to adduct the arm and the head may be seen as well as felt in the axilla. The condition is really a subglenoid luxation but the appearance of the patient is quite different from the usual subglenoid.

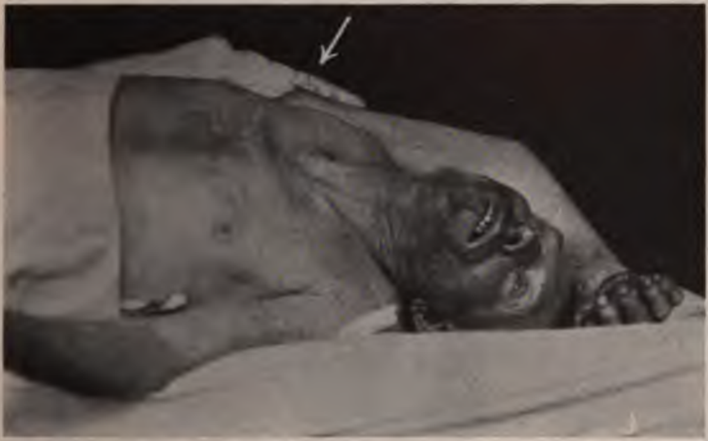


Fig. 82.—Luxatio erecta. Patient was hit by a train and sustained numerous injuries, among them the one shown here. Extension in the altered axis of the arm and direct pressure on the head accomplished reduction without difficulty. Two days later the patient died as a result of associated injuries and immediately following death the dislocation was reproduced, the upper extremity placed in the same position as when first seen and the photograph taken. It was not feasible to take a picture when the patient was first seen but the position and appearance of the extremity as shown here are the same as existed immediately following the accident.

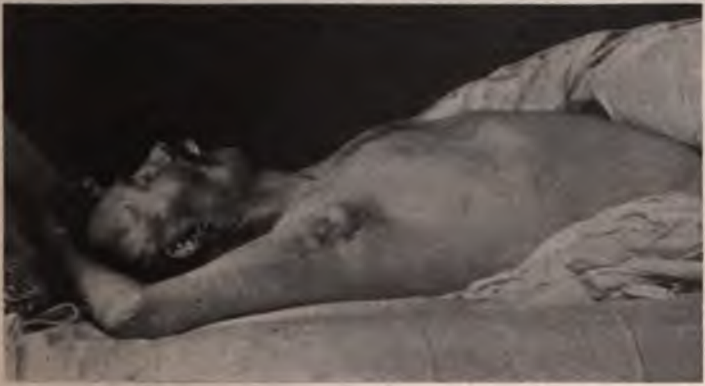


Fig. 83.—Another view of patient shown in Fig. 82.

In the *subacromial type* the head lies behind the glenoid, having been driven across its posterior lip. The anterior portion of the anatomical neck rests on the posterior edge of the glenoid and the articular surface looks into the infraspinous fossa. A prominence will be noted on the posterior aspect of the shoulder while anteriorly the shoulder will be flattened and the acromion prominent. The arm is usually shortened and more or less fixed with the elbow forward. (See Figs. 84 and 85.)

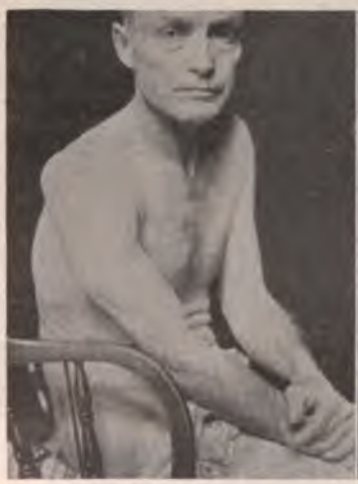


Fig. 84.

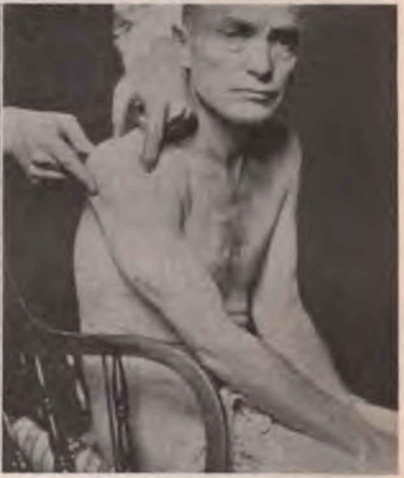


Fig. 85.

Fig. 84.—Posterior dislocation of right shoulder. The humeral head projecting on the posterior aspect of the shoulder is plainly visible. Note shortening of arm and change in axis.

Fig. 85.—Palpation of displaced head. Its position is outlined by the two index fingers and thumbs.

The *subspinous type* is simply an exaggeration of the preceding. The head is driven further backward on the posterior surface of the scapula till it comes to rest under the spine of the bone. This form is very rare and is usually the result of great violence. The symptoms of the subspinous type are those of the subacromial in pronounced form. The arm is shortened, moderately abducted, rotated inward and the elbow on a plane anterior to the chest. The trauma of the head plowing through the tissues causes more or less extravasation of blood and it is usually only a short time following the accident until the skin covering the head of the bone becomes ecchymotic. The further the head passes backward under the

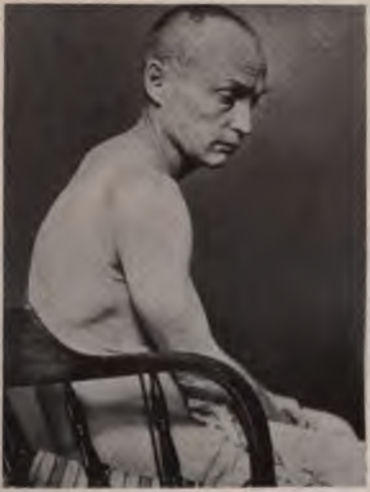


Fig. 86.—Another view of the case shown in Figs. 84 and 85.

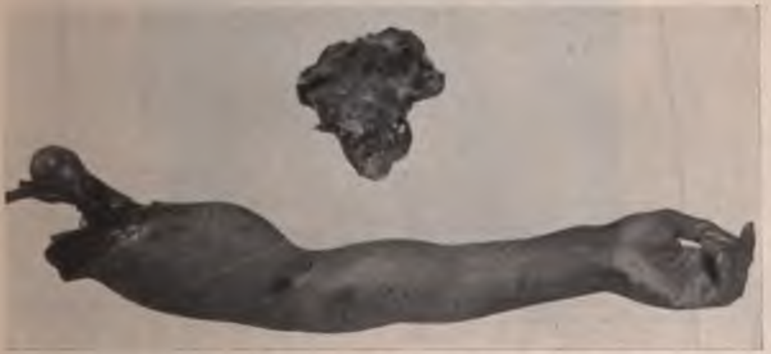


Fig. 87.—Case of complete avulsion of the upper extremity. Case reported because it indicates to some extent the weakest points in the various structures which hold the shoulder together. Capsule torn cleanly from the anatomical neck except over the greater tuberosity where a triangular piece with a base equal to the breadth of the tuberosity and about three-quarters of an inch to the apex. Supra- and infra-spinatous muscles have been torn from the tuberosity and scales of bone corresponding to the insertions of the tendons have been detached. Tendon of teres minor torn across about two inches from its insertion. Subscapularis torn cleanly from lesser tuberosity. Small shreds of the pectoralis major remain attached to the external bicipital ridge, large shred of lower portion of this muscle (about three inches long) remains attached to humerus. Teres major and latissimus dorsi torn cleanly from humerus. Long head of biceps torn near origin. Short head torn a little below the point at which the tendon joins the belly. About two inches of the coraco-brachialis remains attached to the humerus (transverse tear through muscular tissue). Long or middle head of triceps torn transversely below tendon, at about level of the surgical neck. Median and ulnar nerves torn at level of surgical neck. Deltoid torn loose from clavicular and scapular origins with the exception of the portion arising from the acromion. The acromion is fractured transversely about three-quarters of an inch from the tip, the fragment remaining attached to the deltoid. Insertion of deltoid torn cleanly from humerus leaving deltoid eminence free from shreds. Compound comminuted fracture of radius and ulna, and backward dislocation of wrist. (The wrist was reduced before the picture was taken.) Injury sustained in centrifugal wringer in laundry. The patient recovered.

spine of the scapula the more liable the arm is to be fixed in its new axis.

In the extremely rare *upward luxation* the arm is shortened, the acromion fractured and the anterior axillary fold raised. The head of the bone may be felt as a prominence at the point of the shoulder and crepitus is present if the fragment of the acromion is manipulated.

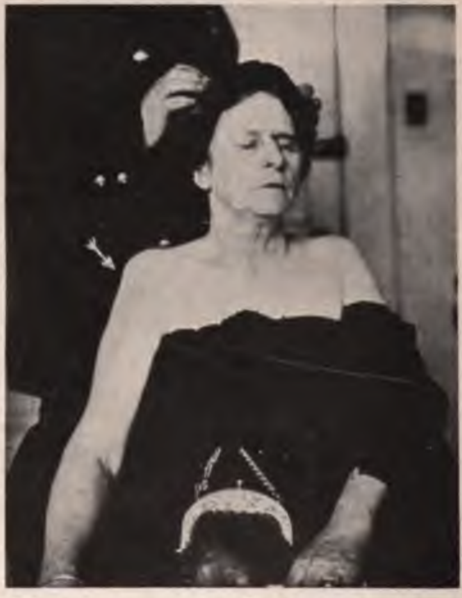


Fig. 88.—Example of a subcoracoid dislocation in a fleshy woman. The symptoms in obese persons are somewhat obscured by the adipose tissue and the condition has not infrequently been overlooked under these circumstances. If the case is carefully inspected, however, there should be no reason for failure in diagnosis.

Diagnosis.—There is a good deal of difference in the deformities of the different types of luxation occurring at the shoulder yet each is characteristic in its way, and if the surgeon is acquainted with the appearance of these deformities there should seldom be any difficulty in recognizing the condition. There is a nice proportion existing between the various symptoms in an ordinary subcoracoid or subglenoid luxation and it is of value for the surgeon to recognize this fact. A given amount of flattening of the shoulder usually goes with a certain degree of change in the humeral axis and lowering of the axillary fold. This relation between the different objective symptoms can best be appreciated by comparing the accompanying illustrations. (Figs. 63 to 77.) These symptoms bear an almost constant relation to each other in simple luxations, but this relation is frequently disturbed when fracture is present. In Fig. 96 flattening of the shoulder is shown without any change in the axis of the humerus. The condition is one of fracture of the anatomical neck with dislocation of the head of the bone. In Figs. 117 and 118 the change in the axis of the humerus is apparent but there is no flattening of the shoulder. The condition is one of fracture of the surgical neck.

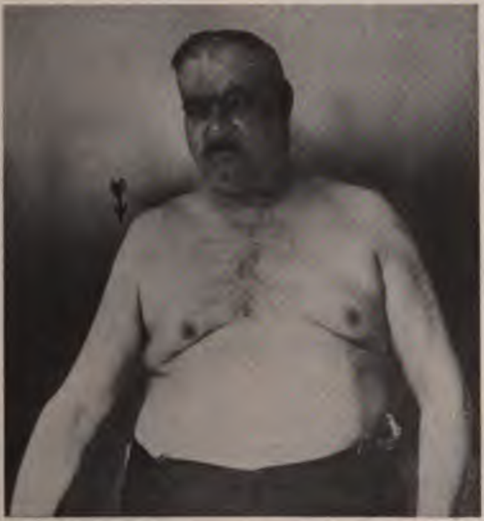


Fig. 89.—Another example of the same condition as shown in preceding illustration. The patient is excessively heavy yet the flattening of the shoulder, change in humeral axis and lowering of the axillary fold are sufficiently pronounced to recognize the condition by inspection alone.

Nearly all the objective symptoms are less pronounced, in fleshy persons, yet this fact should be no excuse for failure to diagnose the condition when present. (See Figs. 88 and 89.) In luxations of the shoulder the patient seldom makes any attempt to support the injured member with the opposite hand but allows the upper extremity to hang limp at the side with a slight inclination of the trunk forward and to the same side. In the exceptional cases in which he does support the arm the act is casual and he will usually release it if requested. This is quite different from the attitude assumed by the patient in the presence of fracture of the humerus. He will then grasp and support the injured member with the greatest care and anxiety, and can seldom be induced to release it when in the standing or sitting position.

The diagnosis must be made on the symptoms, and relief afforded the patient at once. The X-ray is therefore seldom of value except in verifying reduction and in the exclusion of complicating fractures, after the head has been returned to the glenoid cavity.

Treatment.—In all forms of luxation the indications are to return the head to the glenoid cavity at the earliest possible moment and to maintain the parts at rest until the torn ligaments are healed. The methods of reduction vary with the type of luxation.

The subcoracoid luxation is best reduced by what is known as Kocher's method, which consists of three steps and is as follows: With the patient seated in a straight, armless chair the surgeon grasps the elbow with his opposite hand. The elbow is then held firmly against the side while the free hand secures the wrist, brings the forearm to a right angle and then carries it outward away from the median plane. This produces outward rotation of the humerus and opens the rent in the capsule. (See Fig. 91.)

The second step in the manipulation consists in gently forcing the elbow forward and inward across the chest while the patient's hand is maintained in a relatively stationary position. (See Fig. 92.) Resistance is here often encountered and should be met by an insistent springing motion in the direction indicated by the arrow in Fig. 94. It is during this second step that the head of the humerus usually slips back into the socket with a distinct snap. When Kocher's method fails it is usually due to the fact that the surgeon is not maintaining outward rotation of the arm during the time the elbow is being brought forward across the chest. In other words the common fault is in allowing the hand to come forward and inward at the same time that the elbow is being carried across the chest. If reduction is not accomplished during the second step the head is almost sure to remain displaced during the third, and the whole manipulation will have to be repeated.

The third step consists in carrying the hand to the opposite shoulder but is not an essential part of the manipulation. Figs. 91, 92 and 93 not only demonstrate the proper steps and positions of the upper extremity in performing Kocher's method but actually show the reduction of a subcoracoid luxation done before the camera. A study of these plates will give the reader a better

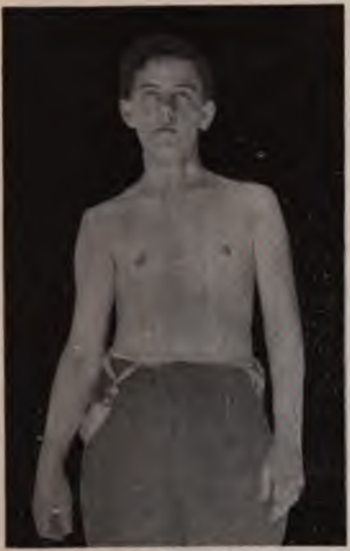


Fig. 90.

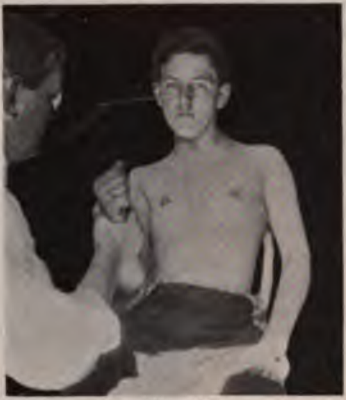


Fig. 91.

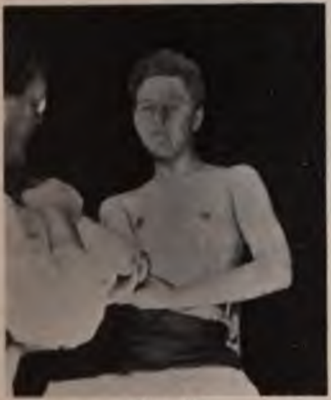


Fig. 92.

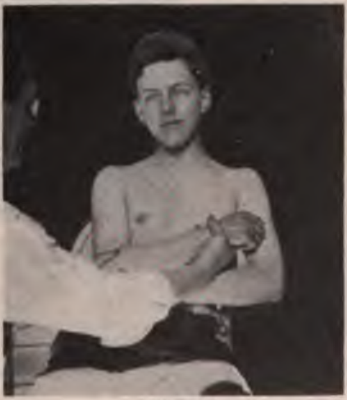


Fig. 93.

Demonstration of Kocher's method on a case of subcoracoid dislocation of the right shoulder. Case presented for treatment immediately following the accident with the usual characteristic symptoms.

Fig. 90.—Appearance of case after being stripped to waist to facilitate examination and reduction.

Fig. 91.—First step in Kocher's method. Head is still displaced as evidenced by the contour of the shoulder.

Fig. 92.—Second step in Kocher's method. (See text.) Note the rounded contour of the shoulder: the head has just been returned to the glenoid.

Fig. 93.—Third step of Kocher's method. Hand is carried to opposite side of chest.

idea of the manipulation than could be conveyed by pages of text.

Many surgeons prefer the recumbent position in performing Kocher's method and in some respects it is more convenient.

Not infrequently the patient hinders the surgeon by a sort of squirming motion in which he arches the body toward the injured shoulder and may even slide off the table away from the operator. This may be avoided by passing a large towel or sheet about the chest and under the dislocated shoulder. The ends lie in front of and behind the opposite shoulder and are used by an assistant in steadying the patient. If a slit be made in a folded sheet and the injured arm passed through it we will have an efficient means of steadying the patient and preventing motion of the scapula.

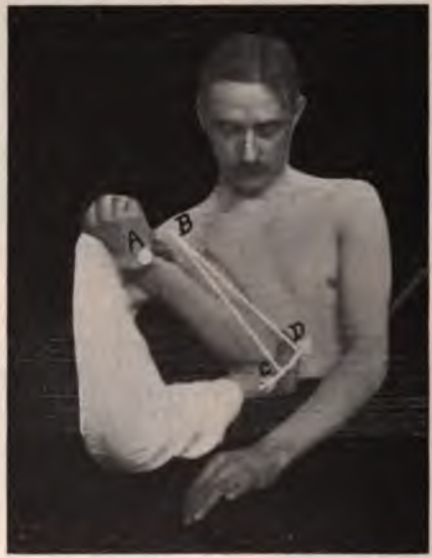


Fig. 94.—This plate shows the essential action in Kocher's method. The patient's elbow should be carried in the direction indicated by arrow *C.D.* while the point *A.* remains stationary or is carried slightly away from the median plane. Resistance is usually encountered and should be met by an insistent, springing motion in the direction indicated by the arrow. If the head of the humerus does not return to the socket during this stage of the manipulation Kocher's method will probably have to be repeated from the beginning. When the capsule has been so extensively torn that no resistance is encountered in carrying the elbow inward Kocher's method will prove useless and reduction will have to be accomplished by horizontal traction and direct pressure with the finger tips on the head of the humerus.

If Kocher's method is properly employed it should be possible, in the usual uncomplicated subcoracoid luxation, to accomplish reduction at the first attempt and without the aid of an anesthetic.

The efficiency of Kocher's method depends on the integrity of the capsule, especially that portion known as the coraco-humeral ligament, and when this has been extensively torn the following method will generally succeed.

Horizontal extension and manipulation.—Raise the arm laterally until it reaches the level of the shoulder, grasp the humerus just above the elbow and exercise traction while an assistant holds the patient about the chest. Place the opposite hand in the axilla, make gentle pressure on the head with the finger tips in the direction of the socket and the luxation will be reduced provided the capsule and coraco-humeral ligament are extensively torn. The lower the head rests on the anterior rim of the glenoid the greater the probability of this method succeeding after Kocher's method has failed. A slight rotary motion of the humerus on its axis during traction will sometimes facilitate replacement. This method will sometimes effect reduction when a displaced tendon of the biceps or detached tuberosity has caused Kocher's method to fail.

Stimson's method is effective though not extensively used. It requires a certain amount of apparatus and time for its accomplishment. The patient is placed on a canvas cot and the arm passed through a slit previously made in the canvas. A weight of about ten pounds is attached to the wrist. Stimson claims an average of about six minutes for reduction, during which time the patient is fairly comfortable. This method may be tried as a last resort before operating in otherwise irreducible cases.

Extension outward and downward.—This method is probably the oldest known and has been in use extensively in England and America up to recent years. Place the patient in a recumbent position and abduct the arm until it occupies an angle of about forty-five degrees with the body; then make traction in the long axis of the humerus while the body is secured by an assistant. The arm may be rotated during traction. It has been customary for years to supplement the above by placing the unbooted heel in the axilla as a fulcrum; when this was done additional force was gained by bringing the patient's hand toward the median plane, thus forcing the upper end of the lever outward toward the glenoid. The use of the heel or any other hard body in the axilla as a fulcrum cannot be too strongly condemned; such methods should be discarded as a relic of barbarism for they have outlived their usefulness. No pressure in the axilla should be used, which is greater than can be exerted by the finger tips of the surgeon, and even then direct pressure on the nerves or vessels should be avoided.

Traction outward and upward is practically the same as horizontal traction, since elevation of the arm above the horizontal is accomplished by rotation of the scapula rather than by alteration in the anatomical relations of the shoulder joint.

Great force was advocated by some of the older writers. Duplay employed horizontal traction by means of an elaborate system of block and tackle, dynamometer, etc. At the present time there is no excuse for the employment of such force. Cases which do not respond to the less violent and more rational methods should be treated by open incision.

Subglenoid dislocations of the shoulder can usually be reduced by Kocher's method though the position of the head below the glenoid is not as favorable for reduction as it is in the subcoracoid form. The lower the head lies on the anterior rim of the glenoid the further back the elbow should be in starting the manipulation. In other words, the lower the head the greater the importance of the first step in Kocher's method. In the typical subglenoid luxation (see Fig. 77) the elbow should not be further forward than the midaxillary line at the beginning of Kocher's method. During the first step the head may be caused to ride upward on the anterior rim of the glenoid cavity. The condition then approaches the subcoracoid type and can be reduced as such. (See Figs. 91, 92 and 93.) The capsule is often extensively torn in the low subcoracoid and subglenoid types and in such instances the head may be reduced by direct manipulation with extension and counter-extension.

The *erect form of the subglenoid* is extremely rare and the few cases seen by the author have been easily reduced by extension in the line of the axis of the displaced arm with digital pressure on the head.

Subacromial and subspinous luxations are usually reduced without difficulty by traction in the axis of the arm; axial rotation and manipulation may sometimes be necessary in addition to extension and counter-extension. The posterior forms are usually accompanied by extensive laceration of the capsule, and hence their easy reduction.

Following reduction the X-ray is of value in determining the presence of fracture and the position of the head. After the head has been returned to the glenoid cavity the following points should be noted to avoid overlooking complications. Place the two arms by the side symmetrically and inspect the case from a point a few feet in front of the patient and again from the side. This is for the purpose of recognizing deformity. The distance between the acromion and external epicondyle should be carefully measured and compared with the uninjured side. If the distance is lessened it usually means complicating fracture of the humerus. If it is increased it commonly indicates that the head is not properly seated in the glenoid cavity. The anterior aspect of the two shoulders should be carefully compared; any undue prominence on the injured side suggests fracture of the upper end of the humerus or the interposition of some obstructing tissue between the head of the humerus and the glenoid. Undue prominence on the anterior aspect of the shoulder and shortening of the arm are symptoms indicative of fracture and are well shown in Figs. 119, 124 and 127.

Compare the cases of fracture of the upper end of the humerus with the cases of luxation of the shoulder in the accompanying illustrations. Motion, sensation, the condition of the reflexes and the circulation should be tested in the injured arm before and after reduction.

The treatment of luxations of the shoulder will vary according to whether or not complications exist.

In simple cases the arm should be immobilized for a period sufficiently long to allow proper healing of the ligaments as indicated in the after-treatment. (See page 79.)

Displacement of the long head of the biceps from its groove may sometimes be corrected by raising the arm well forward, even above the horizontal and employing axial rotation. This complication, however, rarely occurs without fracture of the greater tuberosity, and under such circumstances the tendon and fragment are best replaced and held in position by open incision. Complicating fracture of the upper end of the humerus usually calls for operative intervention to obtain the best results.

Operative Treatment.—Operation is practically never called for to effect reduction of simple uncomplicated cases. It is often indicated in luxations complicated by fracture, in injury to nerves and vessels, in old unreduced luxations, in habitual luxations and in instances in which the dislocation is compound. The details of the operative procedure will depend largely on the nature of the complication.

Fracture of the surgical neck of the humerus complicating luxation is fortunately a rare condition, there being something like 150 reported cases. The older method of treating this double condition was to either secure union of the fracture first and reduce the dislo-

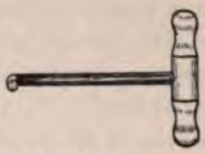


Fig. 95.—McBurney's hook.

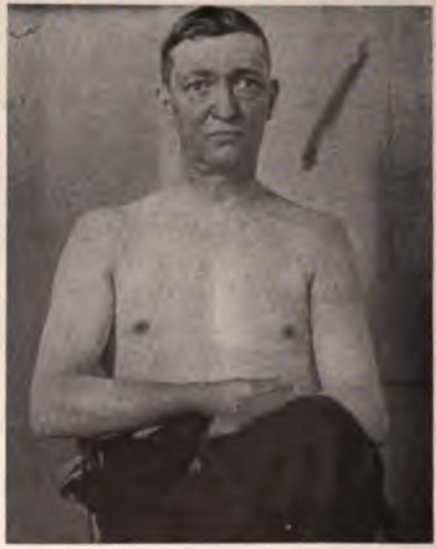


Fig. 96.—Fracture of the anatomical neck of the humerus with displacement of the humeral head beneath the coracoid process. The condition resembles a subcoracoid dislocation of the shoulder on casual inspection. The flattening of the shoulder is the same as seen in dislocations (and properly so since the head is displaced) but it will be noted that the axis of the humerus remains unchanged and the anterior axillary fold is not lowered to the extent seen in uncomplicated subcoracoid dislocations. Moreover the patient supports the injured member with the opposite hand, which is uncommon in dislocations of the shoulder. On manipulating the arm distinct bony crepitus is elicited and an abnormal bony prominence is noted on the anterior aspect of the shoulder. The displaced head could be felt high in the axilla. An X-ray plate confirmed the diagnosis of fracture of the anatomical neck with subcoracoid displacement of the head. Twenty-four hours later ecchymosis appeared covering the anterior portion of the shoulder. Case was operated seven days following the injury. The displaced cap of bone was pulled back onto the upper end of shaft and wired in position. Outer and upper portion of greater tuberosity considerably comminuted. Bony union resulted and function in articulation restored though extreme abduction remains slightly restricted. Wire remains in place at the present time, five years later.

Photograph taken about fifteen minutes following the accident. Fracture produced by fall from bicycle, the blow being sustained on the outer aspect of the shoulder.

cation later, or to obtain a false joint at the seat of the fracture. Both methods must, at the present time, be considered unsurgical and obsolete. McBurney was the first to deal with this condition in a satisfactory manner, treating the fracture and the dislocation at the same time by open incision. He devised a hook (see Fig. 95) by means of which he was able to manipulate the upper fragment so as to return the head to the glenoid, after which the fragments were adjusted, and wired or not as thought best. The end of the hook is inserted into a hole of proper size drilled into the upper fragment, the necessary leverage being thus secured. In *fracture of the anatomical neck* (which is even more unusual than fracture of the surgical neck) the McBurney hook is of little service in reducing a dislocation of the upper fragment. The cap of bone must be handled by means of tenacula because of its friable, cancellous structure, and if reduction is impossible should be excised. Very serviceable joints frequently result after removal of the head.

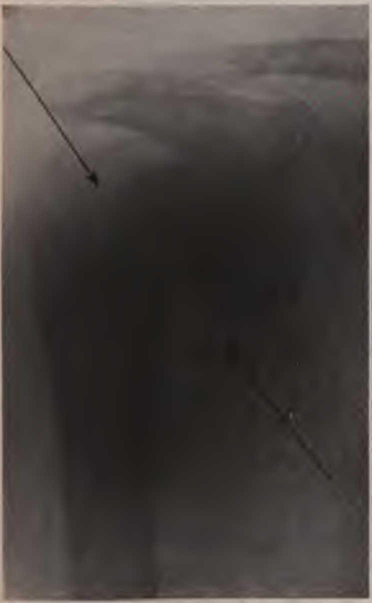


Fig. 97.

Fig. 98.

Fig. 97.—X-ray of case shown in Fig. 96 taken before operation. Fracture of anatomical neck with displacement of the head into the axilla beneath the coracoid.

Fig. 98.—Same case after operation. Head has been replaced and secured in position with a loop of wire. Perfect apposition not possible because of the crushing of cancellous tissue in the upper end of the bone.

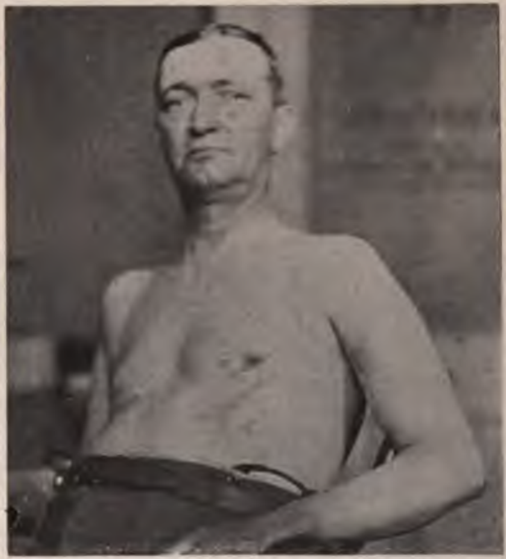


Fig. 99.—Same case after operation and recovery. Picture taken about eight weeks after operation.

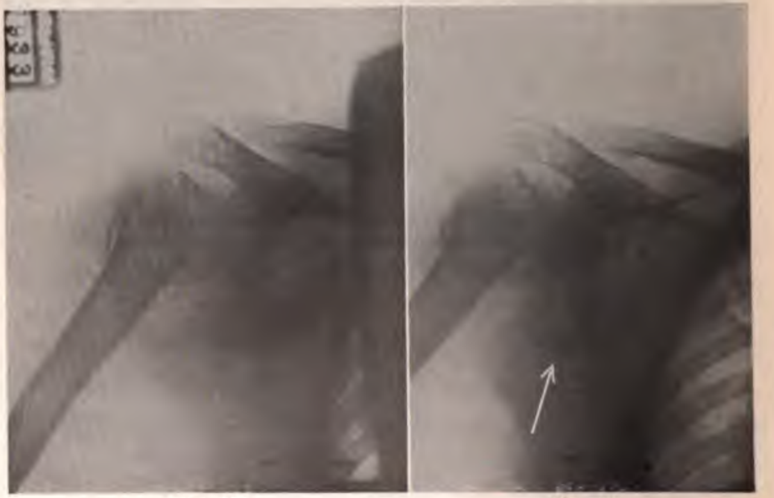


Fig. 100. Fig. 101.

Figs. 100 and 101.—Stereoscopic view of a comminuted fracture of the anatomical neck of the humerus with subglenoid dislocation of the humeral head. The arrow points to the displaced head.

When the head can be replaced it is often found necessary to secure it in position, which is most easily accomplished by wire (see Fig. 98). A peculiar point to be noted here is that the head of the humerus almost never suffers necrosis, even though the upper fragment includes only the articular surface; and it is here that one might expect necrosis since the upper fragment is apparently cut off from its blood supply.

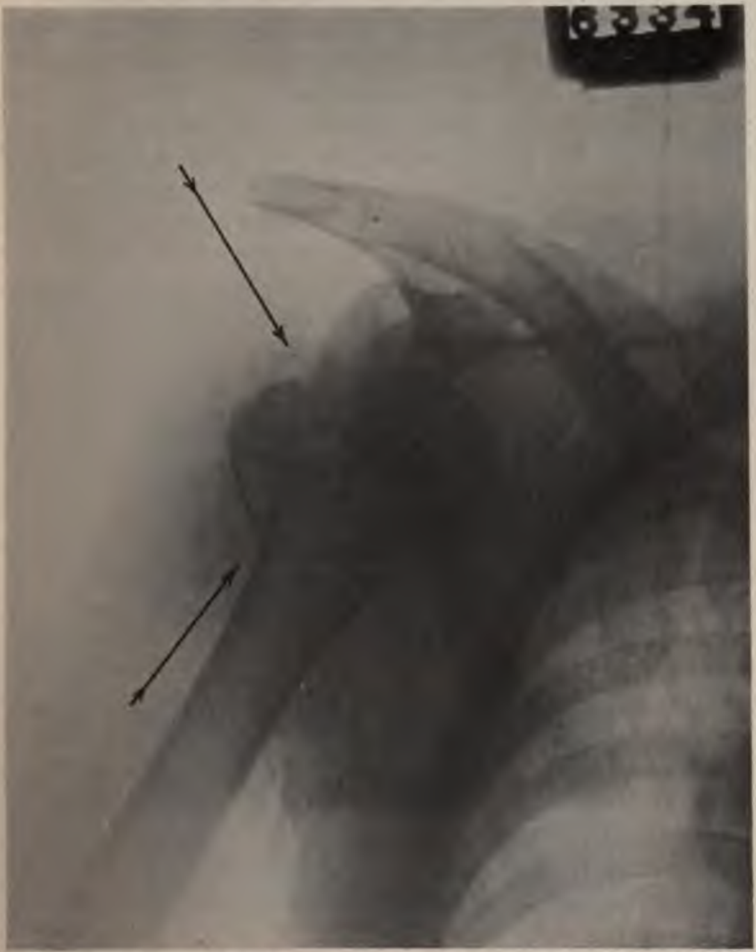


Fig. 102.—Subcoracoid dislocation complicated by fracture of the greater tuberosity. Fragment displaced. Arrows point to lines of fracture.

Either of the tuberosities may be fractured in dislocations of the *shoulder* and may be displaced in the line of pull of the attached muscles. Reposition by open incision and fixation by means of a loop of silver wire will be found most satisfactory.

Two modes of approach are employed, one incision (the external) passes through the deltoid on the outer side of the shoulder, and the other (the anterior) is made in the sulcus between the deltoid and pectoralis major. In making the external incision the circumflex nerve may be encountered in the lower part of the wound and should be avoided. In the low forms of the subcoracoid or the subglenoid dislocations some of the nerves of the brachial plexus or even the axillary artery may lie in front of the head, and in making the anterior incision the surgeon should be on the lookout for these structures.

Injuries to the brachial plexus call for operative intervention, but before this is attempted a careful neurological examination should be made to determine as accurately as possible the extent of the damage and the region of the plexus injured. It should be remembered that the upper part of the plexus may be torn by the pull on the nerves when the humerus is displaced downward. Nothing in an operative way is indicated in instances in which one

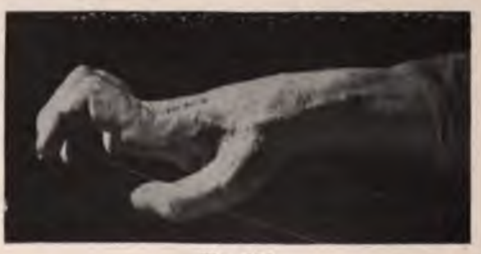


Fig. 103.

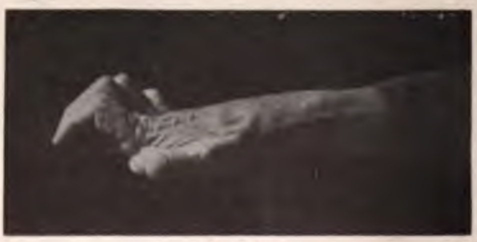


Fig. 104.

Figs. 103 and 104.—Two views of contracture of hand following dislocation of shoulder with injury to brachial plexus.

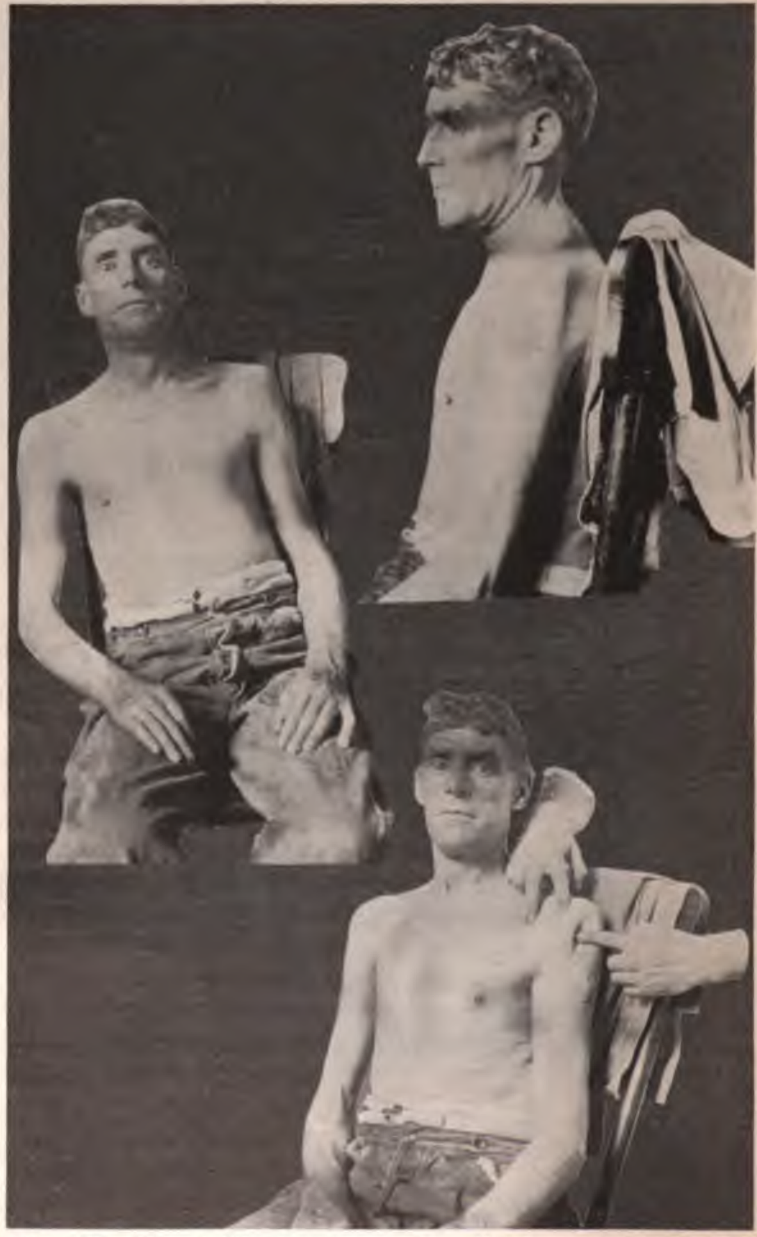
or more of the nerves are bruised or stretched but when laceration occurs the ends should be approximated and sutured together. The patient should be fully appraised of the doubtfulness of the prognosis under such circumstances.

Rupture of the axillary artery or vein with the development of an axillary hematoma (frequently of the pulsating type, when the artery is torn) calls for immediate operative intervention. The artery is temporarily compressed against the first rib to control hemorrhage and an incision made to expose the vessel in the region of the injury. Suture of the injured vessel is rarely possible. Ligation will be indicated.

Old luxations of the shoulder may in some instances be reduced by manipulation, even after the head has been out of the glenoid for four or five months, though the longer the dislocation has existed the less the chance of reduction without open incision (see Fig. 105). Great force should not be used in attempting to reduce these old dislocations because of the liability of injury to vessels or nerves or of producing fracture of the humerus. The fibrous tissue surrounding the head may involve the brachial plexus or axillary artery, and when the head is forcibly returned to the glenoid these structures may be torn. When gentle manipulation does not produce the desired results open incision should be resorted to. The anterior incision is better adapted to freeing the head from the fibrous tissue surrounding it, while the external incision affords better access to the glenoid cavity for the removal of fibrous tissue which so frequently fills it. After the parts have been exposed, the head liberated and the glenoid cavity cleaned out there should be little difficulty experienced in returning the head to its normal position. Old rents in the capsule should be approximated by suture after the edges have been scarified. When the incision enters the joint the divided capsule should be closed with catgut after reduction has been accomplished. Provision for the escape of blood which may subsequently ooze into the wound and joint should be made, so that there may be no dead spaces to favor infection. (See "Open Treatment of Fractures," page 754.)

Recurrent dislocations sometimes become so frequent that the usefulness of the arm is much impaired, and the only relief is through operative intervention, which consists in repairing the rent in the capsule and in plicating the same when necessary.

Compound luxations of the shoulder are extremely rare. The



Figs. 105, 106 and 107.—Three views of an old subcoracoid dislocation of left shoulder of nearly five months' standing at the time the photographs were taken. This dislocation was reduced at the first attempt by means of Kocher's method with the patient in the standing position, which goes to show that cases of long standing are not necessarily operative cases.

treatment of these conditions is essentially operative and should be carried out according to the principles laid down in the chapter on "Treatment of Compound Fractures and Luxations," page 789.

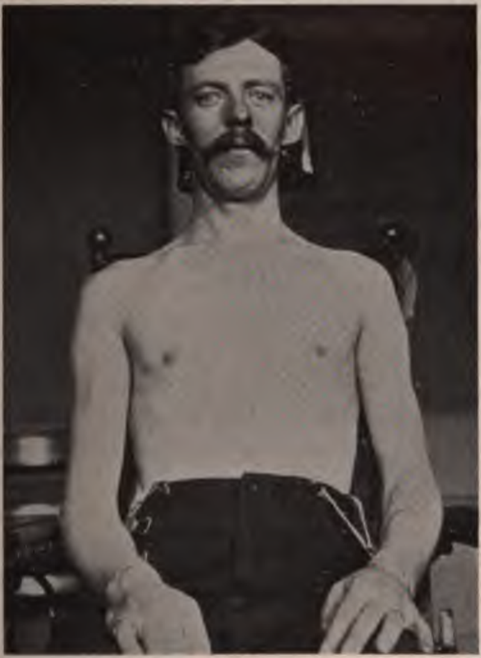


Fig. 108.—This case is a striking example of recurrent dislocation of the shoulder. The photograph was taken immediately following reduction of the seventy-second dislocation of the patient's left shoulder. The use of the left arm is much impaired as the patient is continually guarding against the positions which he has learned from experience are likely to produce displacement. The condition has extended over a period of many years and as a result of the disturbed function the muscles of the left shoulder show a very slight atrophy.

After-Treatment.—In the uncomplicated cases of dislocation of the shoulder the arm should be immobilized for a period of three weeks, but under no consideration should we fail to employ passive motion as soon as the acute traumatic reaction has subsided. This will usually be at the end of five or six days. The arm should be fixed to the side and the forearm carried in a sling. A convenient method is to sew the sleeve of the undershirt to the body of the garment. This prevents the arm from being carried far enough away from the body to strain the capsule. In performing passive motion the surgeon should avoid external rotation and extreme abduction since the former tends to open the rent in the capsule, while the latter causes the injured portion of the capsule to be stretched across the head of the bone. The duration of immobilization should be governed by the extent of the capsular laceration. Prolonged immobilization without passive motion will result in more or less permanent loss of mobility, while on the other hand, unrestricted use of the member following reduction will almost surely be followed by a condition of recurrent dislocation.

When fracture complicates dislocation the arm should be immobilized as in simple fracture of the humerus, from four to six weeks, until union takes place. Passive motion under these circumstances is not permissible prior to union, though careful massage may be begun as soon as the traumatic reaction has subsided. If it is found that the joint is much restricted in its motion after union is firm we may break up the joint adhesions by passive motion, using an anesthetic if necessary. This should not be attempted inside of two months following the injury, and only then when the X-ray shows a good callus at the seat of fracture. (See "Treatment of Fractures of the Upper End of the Humerus," page 97.)

Prognosis.—In the *simple uncomplicated dislocation* (especially of the subcoracoid type) the restoration of function should be practically complete provided passive motion is instituted early and the patient is prevented from using the arm before the ligaments have healed. The prognosis is rendered worse according to the presence and nature of complications. *In injury to the axillary* vessels collateral circulation is usually established if the member is properly cared for. *Injury to the brachial plexus* or some of its branches is not exceptionally rare and deserves a most guarded prognosis. It is true that injury to nerves has occurred during reduction, especially in cases in which the heel has been used as a fulcrum in the axilla, but on the other hand the surgeon not infrequently has been blamed for paralyses which were produced at the time of the accident and for which he was in no way responsible. These unfortunate circumstances demonstrate the value of examining the condition of the reflexes and of motion and sensation in the arm before any attempt at reduction is made. *Pressure on the nerves* by the head of the bone is usually accompanied by transitory symptoms and complete recovery. *Laceration of the nerves* is followed by permanent paralyses unless the nerve ends are united. Operation renders the prognosis better, though recovery is usually prolonged and often incomplete, especially if the condition is of long standing at the time of operation. In *old unreduced luxations* the patient sometimes develops surprisingly good use of the arm as years go on. The betterment of the condition by operation is usually quite gratifying. Most *recurrent luxations* can be completely cured by operation. *Compound luxations* are usually produced only by great trauma and the prognosis will depend on the injury sustained by the surrounding soft tissues and the subsequent development of infection. The prognosis of these luxations is grave though modern operative treatment has improved the outlook greatly.

CHAPTER VII.

FRACTURES OF THE UPPER END OF THE HUMERUS.

Surgical Anatomy.—The upper end of the humerus is deeply seated and extremely difficult of palpation unless dislocated. It will be noted that the normal lateral prominence of the shoulder is due to the head of the humerus beneath the deltoid muscle, and not to the acromion. The upper extremity of the bone is composed of cancellous tissue, as shown in Fig. 110, there being only a thin layer of compact bone on the surface. The manner in which the compact tissue of the shaft grows rapidly thinner as the end of the bone is approached is well shown in the section of bone just referred to in Fig. 110. The internal structure is deserving of careful study since it explains some of the deformities and the variations in the types of fracture occurring at different levels. In addition the surgeon should appreciate the internal structure as well as the surface form in performing operations for the direct fixation of fragments. The attachment of the capsule corresponds to the anatomical neck except on the inner aspect of the bone where it is attached a little below the line of the neck. The muscles attached to the upper end of the bone are important in explaining the deformities occurring in the presence of fracture. The muscles inserted into the greater tuberosity are, from before backward, the supraspinatus, infraspinatus and teres minor. These three muscles arise from the supraspinous fossa, infraspinous fossa and axillary border of the scapula respectively, and pass in almost straight lines to their insertions into the greater tuberosity. These muscles when unopposed by the weight of the limb and the muscles inserted into the shaft, tend to produce outward rotation and abduction of the upper fragment. The subscapularis arises from the subscapular fossa and passes directly to its insertion into the lesser tuberosity. When unopposed it tends to produce inward rotation. It lies to the inner side of the joint and is in contact with the capsule. When the shaft is separated from the upper end of the bone the muscles attached in the region of the bicipital groove tend to produce inward displacement of the upper end of the lower fragment. These muscles are the pectoralis major, teres major and latissimus dorsi.

Fractures of the upper end of the humerus may show great variation, yet in most instances the injury will conform more or less accurately to one or more of the following types: fracture of the anatomical neck, fracture of the tuberosities, fracture of the surgical neck and separation of the epiphysis.

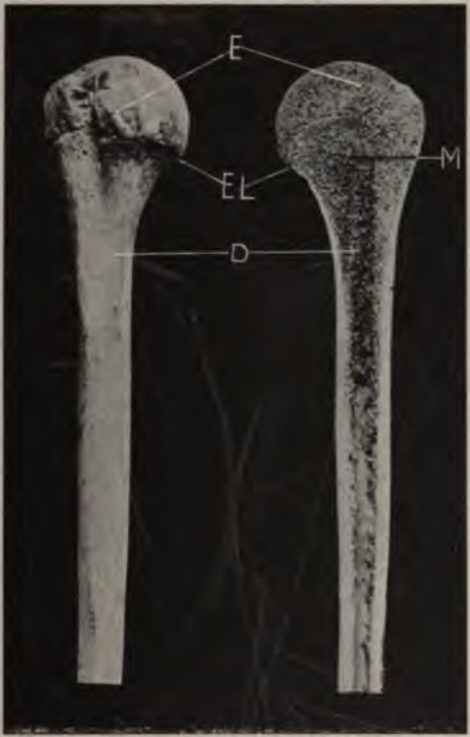


Fig. 109. Fig. 110.

Fig. 109.—Upper end of humerus in young subject. Note position of epiphyseal line. *E.*, epiphysis; *E.L.*, epiphyseal line; *D.*, diaphysis.

Fig. 110.—Coronal section of same bone. *M.*, metaphysis. Note the manner in which the diaphysis projects into the epiphysis and the relative distribution of cancellous tissue.

Fracture of the anatomical neck occurs in middle and old age and is usually the result of direct violence. The line of fracture seldom corresponds exactly with the anatomical neck. The most usual variations of fracture of the anatomical neck are: fracture of the anatomical neck through its inner half or two-thirds (the outer portion of the fracture being so placed as to include the greater tuberosity with the upper fragment),—splitting of the upper end of the bone with fracture of the anatomical neck and impaction of the head into and between the tuberosities,—fracture of the anatomic neck in its outer half with a portion of the inner side of the shaft attached to the upper fragment. The line of fracture very rarely follows the anatomical neck throughout, but when it

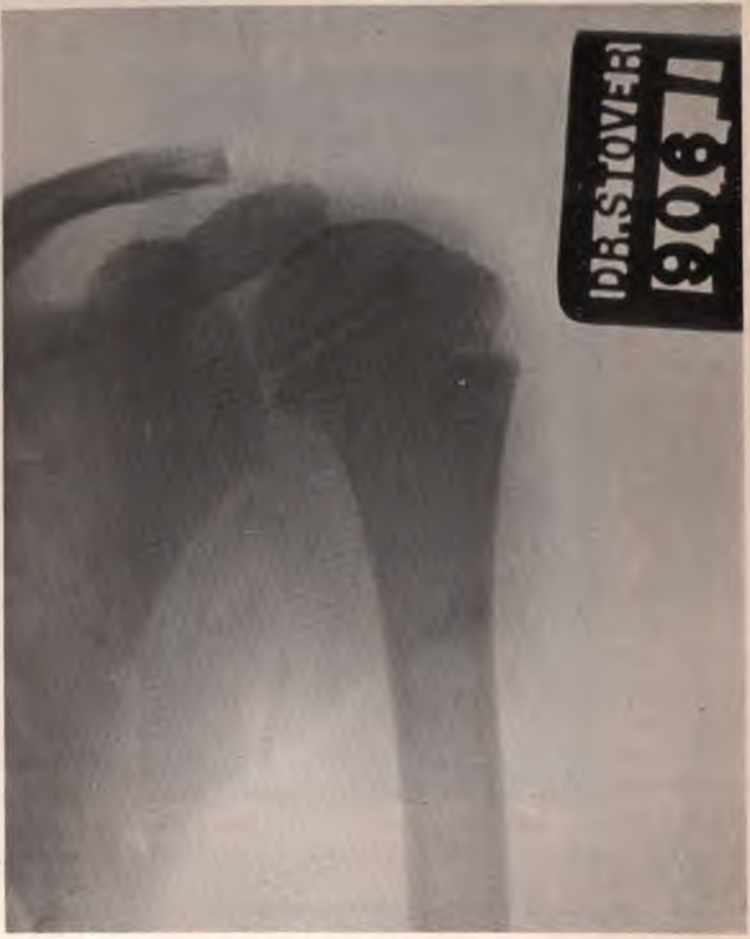


Fig. 111.—Röntgenogram of shoulder of child nine years of age. Note the relations of the epiphyseal cartilage and compare with Figs. 109 and 110.

does the upper fragment is left free from muscular and ligamentous attachments and is as likely to be displaced in one direction as another. Fracture of the anatomical neck is usually accompanied by more or less crushing of the internal cancellous tissue in the upper end of the bone and impaction of the fragments is not uncommon.

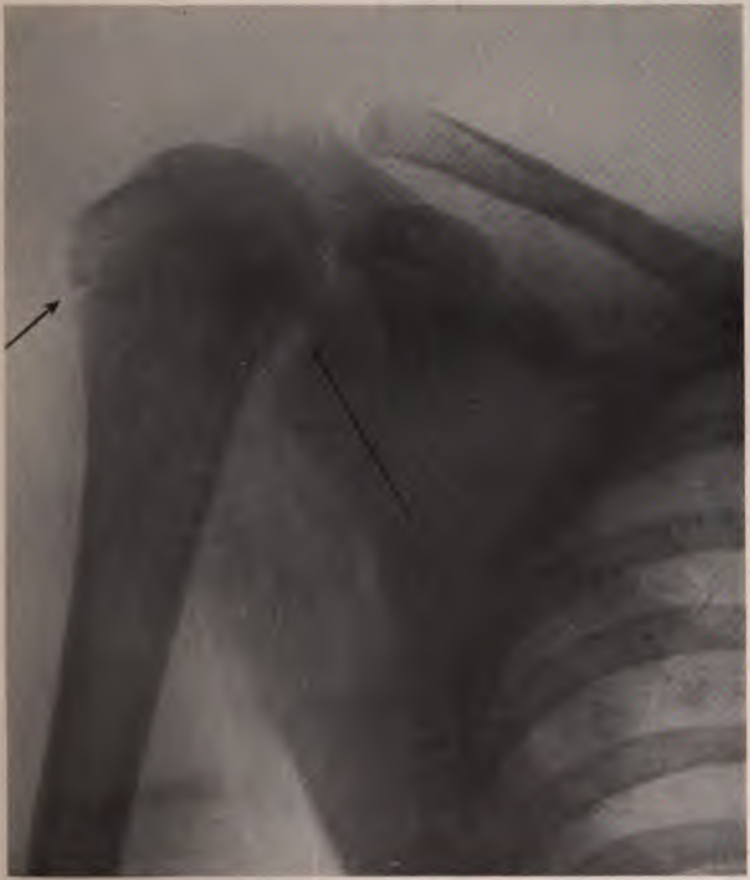


Fig. 112.—Fracture of anatomical neck of humerus. Fracture in this region seldom follows the anatomical neck throughout but includes the upper portion of the greater tuberosity with the head, as in this case.

Fractures of the tuberosities as isolated injuries are extremely rare. They are most commonly associated with dislocations of the shoulder and may occur with fracture of either the anatomical or surgical neck. Avulsion of a scale of bone from the greater tuberosity corresponding to the insertions of one or more of the attached muscles has been reported in a few cases and is the result of muscular action. Undoubtedly this condition has existed in many cases and been mistaken for a "sprain." Isolated fracture of the lesser tuberosity is even more rare than fracture of the greater tuberosity. It is known to have been avulsed by overaction of the subscapularis. Fracture of the lesser tuberosity is most often seen as a complication of dislocations of the shoulder, especially those of the posterior variety. The fragment is displaced by the pull of the attached

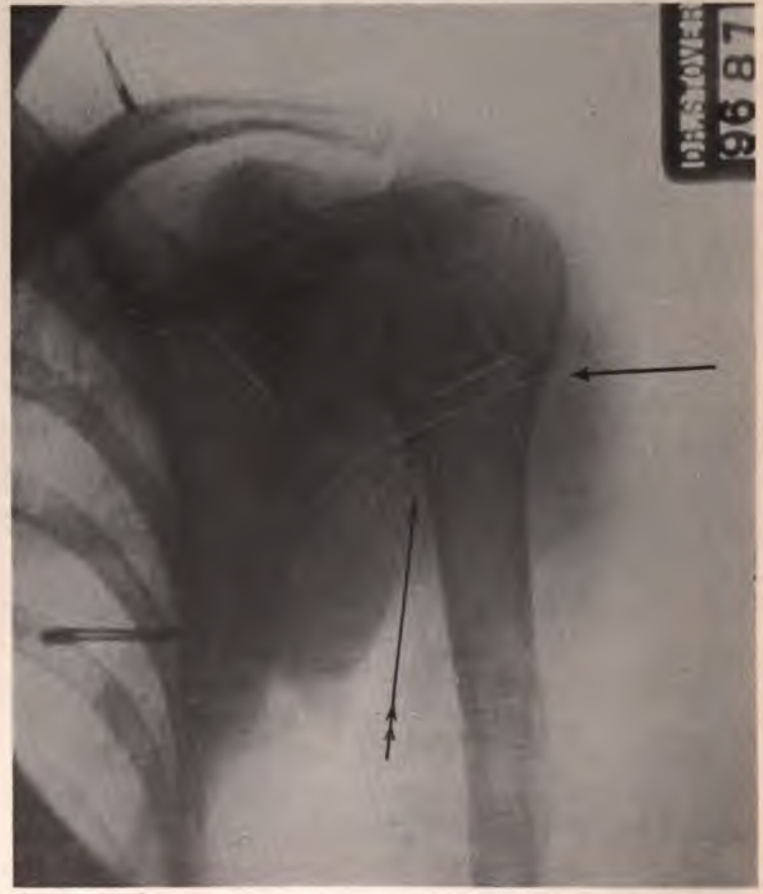


Fig. 113.—Fracture of surgical neck of humerus. Good position of fragments.

muscle and usually lies in the axilla internal to and below the head.

Fractures of the surgical neck are much more common injuries. The surgical neck is that portion of the bone between the epiphyseal cartilage and the insertions of the pectoralis and teres major. When fracture occurs in this region the lower fragment will be displaced inward by the pull of the pectoralis major, latissimus dorsi and teres major and overriding will be effected by the action of the biceps, triceps, deltoid and coraco-brachialis. The upper fragment will be controlled by the muscles attached to the tuberosities and is usually displaced forward and may be abducted or adducted. The lower fragment may be driven upward into the upper fragment, or the serrated surfaces sufficiently engaged to partially or completely oppose the displacing action of these muscles.

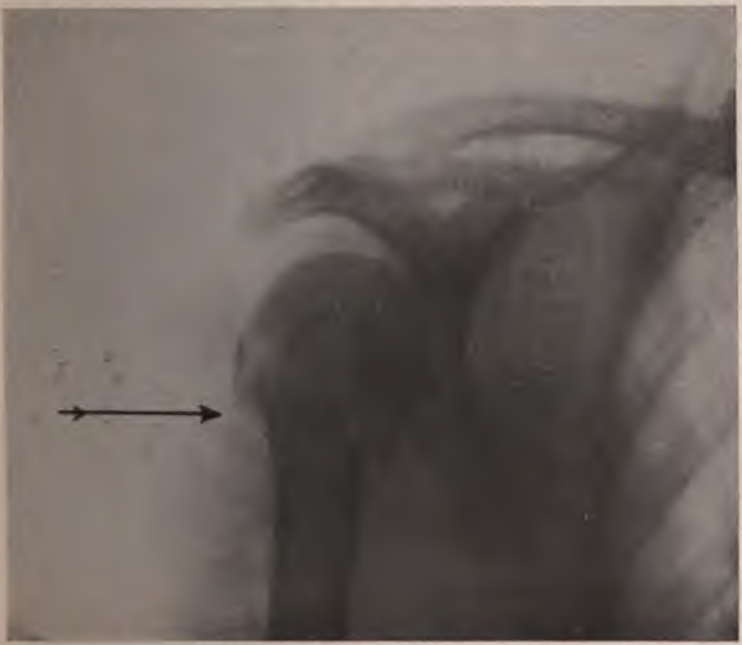


Fig. 114.—Fracture of surgical neck with considerable comminution along line of fracture.

Pronounced inward displacement of the upper end of the lower fragment may produce injury to vessels and nerves. The lesions will be similar to those already mentioned as occasionally complicating dislocations of the shoulder.

Epiphyseal separation of the upper end of the humerus is not an uncommon accident. The upper epiphysis of the humerus is ossified from two centers, one for the head and one for the greater tuberosity. Occasionally an additional center is seen for the lesser tuberosity. The ossific center for the head is present at birth, that for the greater tuberosity is first seen during the third year. When the lesser tuberosity is ossified by a separate center it is usually not seen until the fifth year. The head and greater tuberosity are fused at the sixth year so that the epiphysis is one piece of bone. The epiphysis joins the shaft at about the twentieth year. Separation of the epiphysis may occur at any time prior to the twentieth year, but is most commonly seen from the ninth to the seventeenth years. The position of the epiphyseal cartilage is well shown in Figs. 110 and 111. It will be noted that the cartilage is roughly horizontal but that the center is much higher than the margins. This is probably due to the fact that the epiphysis is ossified from two centers. The conical conformation of the end of the diaphysis accounts for the fact that recurrence of deformity is seldom seen following reduction of an epiphyseal separation in this region. The joint cavity may be opened, but more often is not. When the diaphysis is displaced the deformity is similar to that seen in

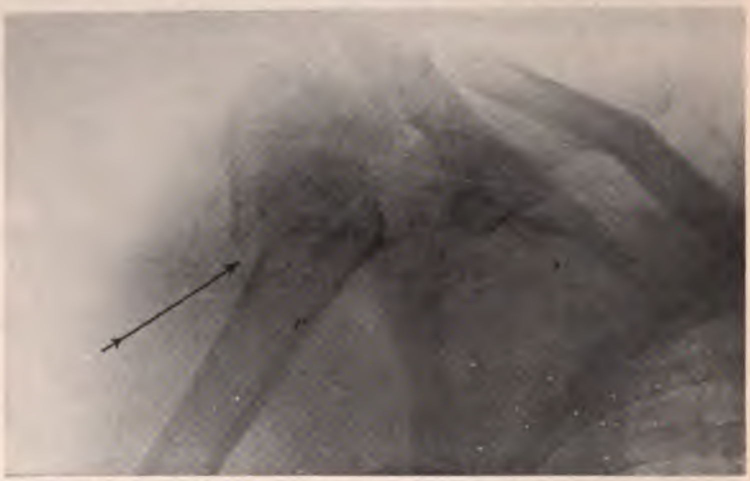


Fig. 115.—Fracture of surgical neck with deformity. Comminution of upper fragment.

fractures of the surgical neck; that is, the upper end of the shaft is pulled inward by the action of the pectoralis major, teres major and latissimus dorsi and raised by the muscles of the arm.

Etiology.—Fractures of the upper end of the humerus are the result of direct and indirect violence. Fracture af the surgical neck is the most common break in this region. Fracture of the anatomical neck occurs mostly in the aged. Epiphyseal separations are seen only in children and adolescents. Various types of fracture of the upper end of the humerus are occasionally seen as complications of luxations of the shoulder.

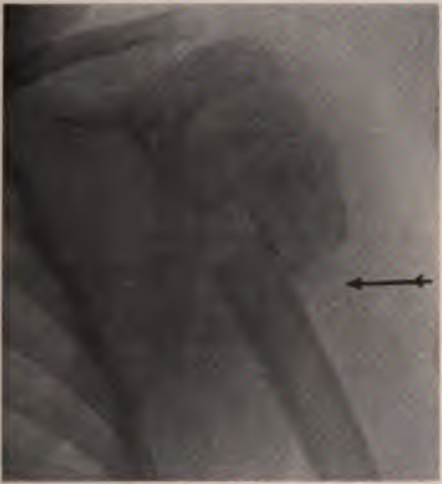


Fig. 116.—Transverse fracture of the surgical neck with pronounced deformity.

Symptoms.—The symptoms accompanying fracture of the upper end of the humerus will vary according to the nature and severity of the lesion. If the fragments are free the symptoms will usually be pronounced. When impaction exists the symptoms may be so slight at first that the patient continues to use the part, although there is always more or less pain and discomfort. Swelling about the shoulder is almost constant and an abnormal prominence anteriorly (see Figs. 119 and 124) usually accompanies fractures in this region. Function is completely lost in unimpacted cases but is often only partially so when the fragments are impacted. Pain is constant though the degree is quite variable. It is always more severe in unimpacted cases. Ecchymosis usually develops within twelve to twenty-four hours following the fracture. The attitude of the patient is usually characteristic. The upper part of the trunk is inclined forward and toward the injured side, and the injured arm is supported with the opposite hand. This attitude is usually not assumed in isolated fracture of one of the tuberosities but only when there is solution of continuity in the humeral shaft.

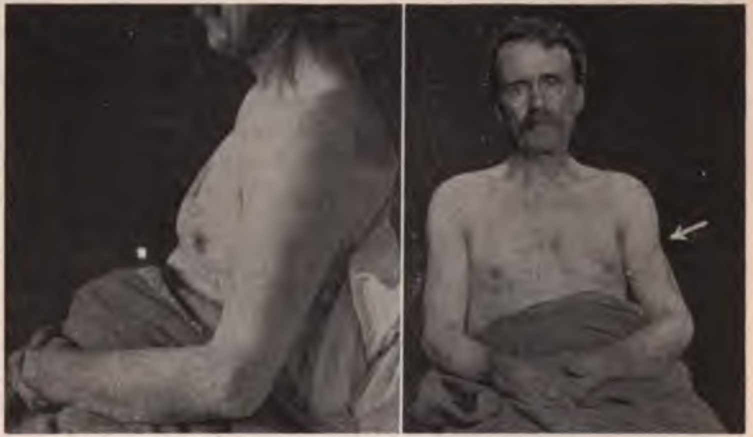


Fig. 117. Fig. 118.

Figs. 117 and 118.—Two views of recent fracture of the surgical neck of the humerus. Note the abnormal prominence on the anterior aspect of the shoulder, also change in axis of humerus which is not accompanied by flattening of the shoulder as seen in dislocations. Very slight shortening of the arm present. Note how patient grasps the injured member with opposite hand (an attitude seldom seen in dislocations of the shoulder). Picture taken about half an hour following the accident.

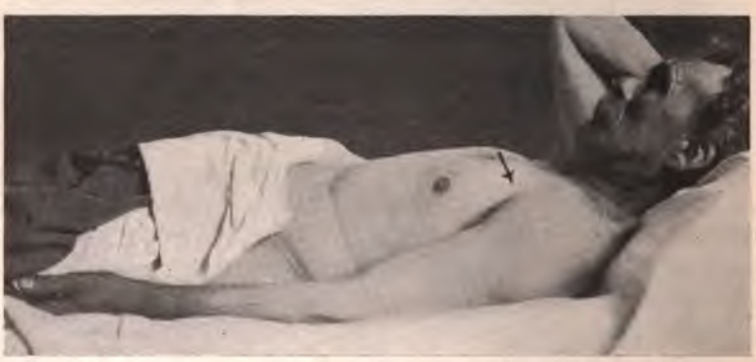


Fig. 119.—Same case seen in the recumbent position. Note that the abnormal prominence on the anterior aspect of the shoulder is not changed by the patient's lying down.

In fracture of the anatomical neck impaction is not uncommon and accordingly the symptoms may not be severe. Pain is present on moving the shoulder. Swelling is constant. Abnormal mobility will be present unless the fracture is impacted but the proximity of the shoulder joint to the point of false motion often renders the condition difficult of recognition. Deformity may be present but is much less common than is the case in fracture of the surgical neck. Slight flattening of the shoulder may be noted but is uncommon. The humeral neck is usually thickened. Alteration in the humeral axis may be apparent in the uncommon cases in which there is lateral displacement of the fragments.

In fracture of the greater tuberosity the power of outward rotation will be diminished and motion of the shoulder, especially rotation, will be attended by pain. Swelling is variable. Local tenderness is constant. By applying a stethoscope to the shoulder and rotating the humerus it may be possible to detect crepitus which would otherwise escape recognition. The normal joint sounds and those occurring in arthritis should not be confused with true crepitus. It may in some cases be possible to palpate the displaced fragment. *In fracture of the lesser tuberosity* the power of internal rotation will be lost or lessened and it may be possible to palpate the displaced fragment in the axilla, below and to the inner side of the humeral neck.

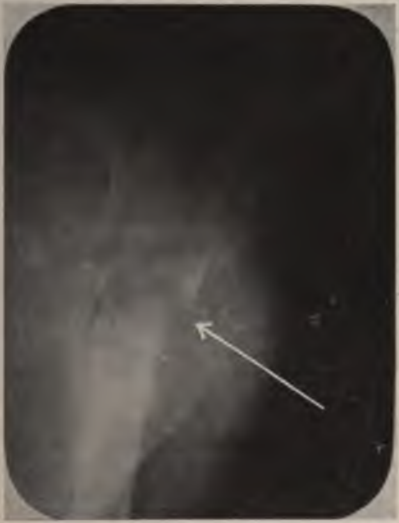


Fig. 120.—X-ray of case shown in Figs. 117, 118 and 119. Fracture of surgical neck of humerus.

In fracture of the surgical neck the symptoms are more pronounced and constant. Impaction is rare, pronounced deformity is the rule. The upper end of the lower fragment is usually displaced upward, forward and inward, or upward and inward. The more pronounced the lateral displacement the more apparent will be the change in the axis of the humeral shaft. Pain is usually severe and the suffering greatly increased by motion of the shoulder. Injuries to nerves and vessels are unusual though they are more common in this fracture than in any other occurring in the upper end of the humerus, and the accompanying symptoms are similar to those described under "Dislocations of the Shoulder," page 76. Pain, mobility, crepitus, loss of function, swelling, ecchymosis and deformity are more pronounced and characteristic in fracture of the surgical neck than they are in any other fracture occurring in the upper end of the humerus. The accompanying illustrations will give the reader a good idea of the usual clinical picture accompanying fractures of the surgical neck.

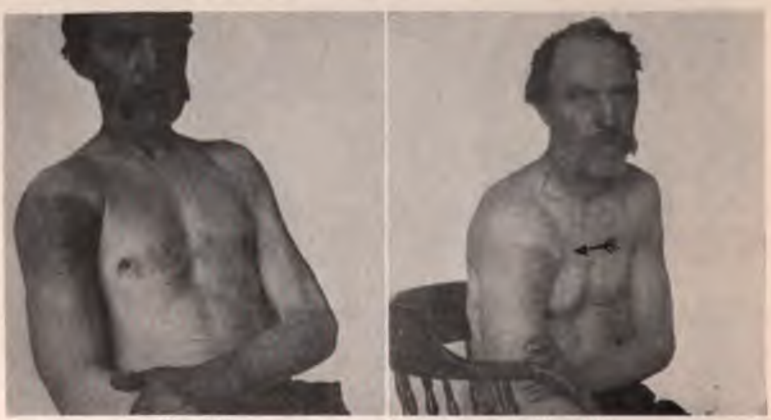


Fig. 121. Fig. 122.

Figs. 121 and 122.—Fracture of surgical neck of humerus twelve hours after injury. Note the undue prominence of the shoulder anteriorly which is greater than would be present in simple swelling of the shoulder following sprain. Note also the ecchymosis which almost never follows dislocation. Note the attitude of the patient in grasping the injured member with the opposite hand. In dislocations the patient seldom makes any attempt to support the injured member but in fractures of this region it is often difficult to get him to let go of it even for an instant. Injury sustained in this case by blow on the upper and outer aspect of the arm. Patient about 60 years of age.

In epiphyseal separations of the upper end of the humerus the symptoms are similar to those seen in fractures of the surgical neck. Displacement, however, is not as constant, loss of function is variable, and crepitus soft and cartilaginous. Separation of the

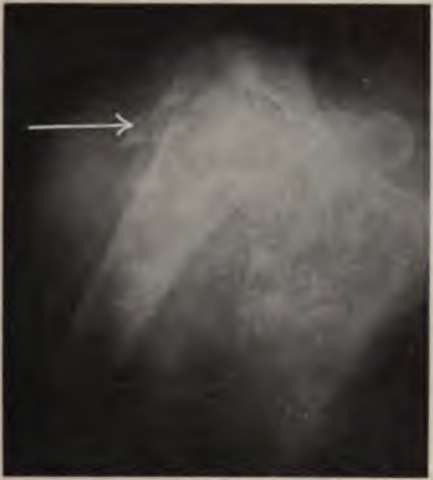


Fig. 123.—Röntgenogram of case shown in Figs. 121 and 122.

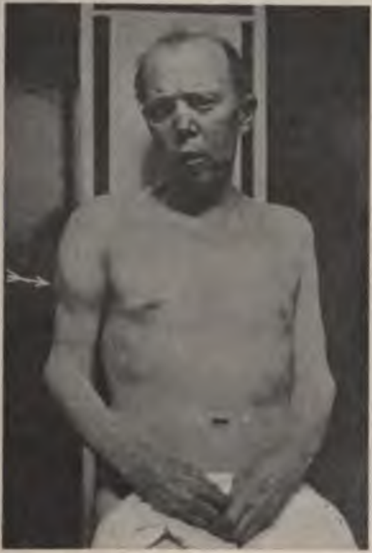


Fig. 124.—Low fracture of sargical neck of right humerus. Note the shortening of the arm on injured side. The lower end of the upper fragment is displaced forward, producing the abnormal prominence indicated by arrow, while the lower fragment is displaced upward. Note the tight grasp on the fingers of the injured member. This attitude was assumed even after the patient was requested to release his hold on the forearm higher up. (See Diagnosis.) Only slight change in humeral axis. Photograph taken about three hours following injury. (Note evidence of syphilis in nose and compare with Figs. 462 to 465.)

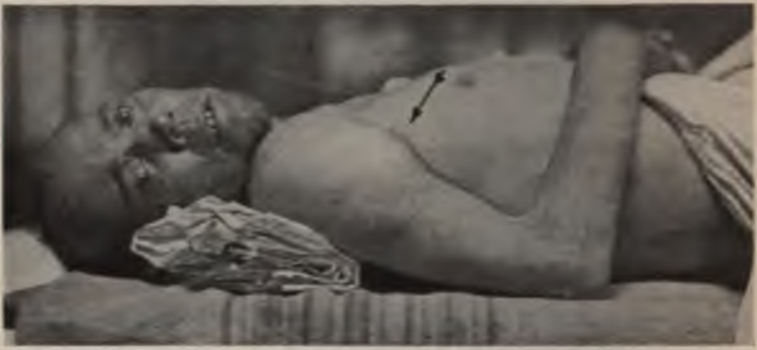


Fig. 125.—Same case (Fig. 124) seen in recumbent position. Note that the change in position does not influence the prominence on the anterior aspect of the shoulder. It is easy to see that the prominence indicated by arrow is produced by forward displacement of the upper fragment since the axis of the arm and therefore of the lower fragment is only slightly altered. Compare with Fig. 127, in which both fragments are angulated.

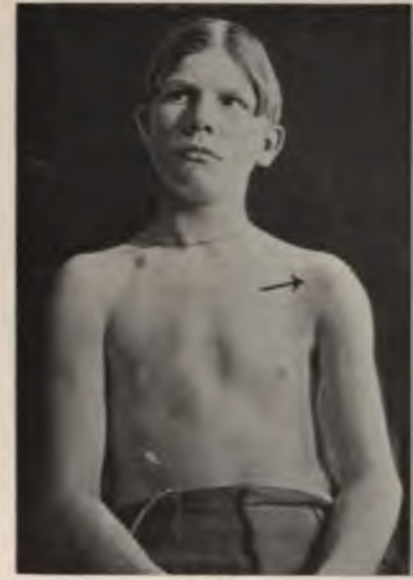


Fig. 126.

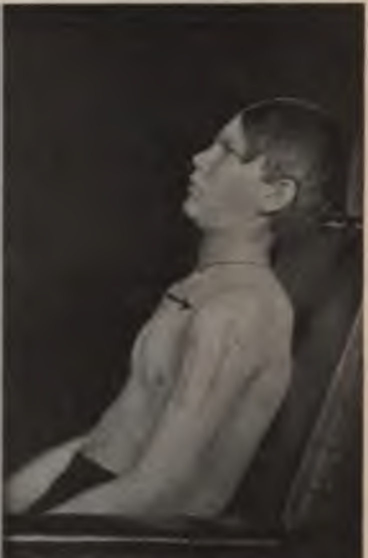


Fig. 127.

Figs. 126 and 127.—Youth, age 15 years. Fell about fifteen feet and struck on left shoulder. Pain and disability present on rising from ground. Promptly attended by physician who diagnosed dislocation and treated same by Kocher's method. Case seen by another physician a few days later. First seen by author about three weeks following injury when photographs were taken. Note prominence on anterior aspect of shoulder and shortening of arm, both signs indicative of fracture. Pen outline on arm indicates the positions of the fragments as revealed by palpation. Arm can be carried only a short distance forward because of the deformity interfering. Diagnosis confirmed by X-ray. (See Fig. 128.)

upper epiphysis may occur without displacement and the loss of function may be only partial. Under these conditions the surgeon may fail to recognize the nature of the injury. When deformity is present the upper end of the diaphysis is usually displaced forward and inward and on examination of the shoulder the lesion is noted at a higher level than that seen in fracture of the surgical neck. The anterior aspect of the shoulder is characteristic. The prominence caused by the upper end of the diaphysis can, as a rule, be appreciated by inspection alone.

An epiphyseal separation without deformity may easily escape recognition immediately following the injury. If the shoulder is not immobilized subsequent strain is likely to produce displacement and the characteristic deformity, together with the accentuation of the symptoms, discloses the nature of the injury.

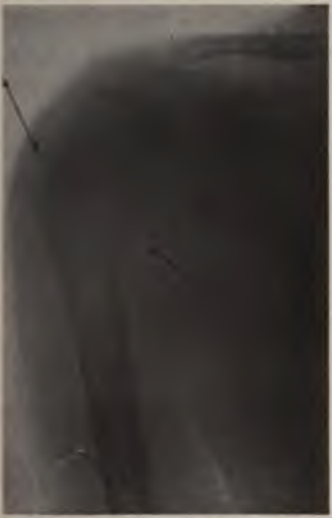


Fig. 128.—X-ray of case shown in Figs. 126 and 127.

Diagnosis.—The diagnosis of fractures of the upper end of the humerus is based on the symptoms just enumerated and when these are typical there should be little difficulty in determining the nature of the injury. A thorough and systematic examination of the shoulder should be made in every case and the possibility of associated fractures of the clavicle and of dislocations of the shoulder and acromio-clavicular joint should be kept in mind.

With the patient seated in a straight chair the arms are placed in symmetrical positions and the parts carefully inspected before any manipulation is attempted. Much can be learned by inspection alone and if this source of information is fully utilized much unnecessary manipulation can, as a rule, be avoided. In fractures of the clavicle the shoulder is usually lowered but the arm itself is not shortened. The over-riding deformity so common in fractures of the clavicle is usually apparent. In dislocations of the shoulder the change in humeral axis, flattening of the shoulder and lowering of the axillary fold should indicate the nature of the injury at a glance. The attitude in dislocations is characteristic in that the patient seldom makes any attempt to support the injured member with the opposite hand. In fractures of the upper end of the humerus the injured arm is grasped and supported with the greatest anxiety. Both active and passive motion are restricted in dislocations while abnormal mobility is the rule in fractures. Ecchymosis is common about the shoulder within twelve to twenty-four hours following a fracture, but in luxations it is almost never seen except in the rare subspinous type. Flattening of the shoulder is sometimes seen in fractures of the anatomical neck but it is never as pronounced as in dislocations and is not accompanied by change in the humeral axis.

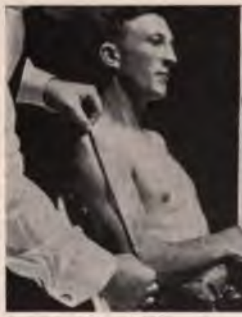


Fig. 129.

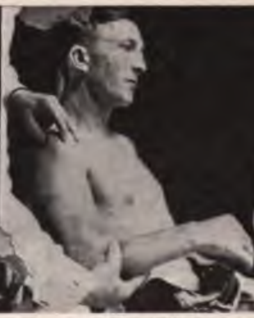


Fig. 130.

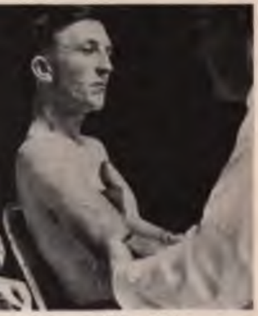


Fig. 131.

Fig. 129.—Measuring humeral length—from acromion to external epicondyle.
Fig. 130.—Palpating humeral head through deltoid.
Fig. 131.—Palpating humeral head with finger tips pressed into axilla.

The head of the humerus should be palpated through the deltoid and again through the axilla. If the arm is carried through rotation while the head is palpated the surgeon may determine to his satisfaction whether or not the head follows the movements of the shaft. The shaft of the humerus should be measured from the edge of the acromion to the external epicondyle and compared with the opposite side. Shortening usually means fracture, while lengthening is indicative of the more common types of dislocation (subcoracoid and subglenoid). The coracoid process should be palpated where it approaches the surface about an inch below the junction of the middle and outer thirds of the clavicle. The clavicle, acromion and spine of the scapula should be palpated. The arm should be carried through the normal range of motion and restriction in any given direction and increase of pain should be noted.

Fracture of the neck of the scapula may be difficult to distinguish from fracture of the upper end of the humerus. If fracture of the upper end of the humerus can be excluded and still there is abnormal mobility of the upper end of the bone with crepitus, the symptoms are indicative of fracture of the glenoid or neck of the scapula. It may be possible in some cases to palpate the margin of the displaced glenoid in the axilla.

Differentiation of fractures of the upper end of the humerus from luxations of the shoulder and fractures and dislocations of the clavicle is usually not difficult, but to distinguish between the different types of fracture occurring in the upper end of this bone is often not an easy matter without the aid of the X-ray. The symptoms of fracture of the anatomical neck, surgical neck, tuberosities and epiphyseal separations have been enumerated and will serve in making a differential diagnosis in typical cases pending the making of a Röntgenogram.

The possibility of increasing the damage to the soft parts should be borne in mind and manipulation should be as gentle and brief as possible. Motion, sensation and the deep reflexes of the upper extremity should be tested to recognize complicating injuries to the nerves and vessels. The condition of the circumflex may be ascertained by tapping the deltoid and noting the contraction of its fibres.

If manipulation is especially painful or the swelling pronounced, the examination is best conducted under anesthesia.

Treatment.—Reduction of the fragments should in most cases be done under anesthesia. A careful consideration of the physical signs and symptoms will, as a rule, afford the surgeon sufficient information concerning the fracture to correct the deformity. The parts should then be immobilized and an X-ray taken to determine the position of the fragments and the details of the fracture.

The upper end of the shaft may be displaced in any direction and accordingly the manipulations of reduction will vary in different cases. The usual deformity, however, consists in an upward and inward displacement of the upper end of the lower fragment. Reduction will therefore usually consist in forcing the upper end of the shaft outward, while traction is being exerted on the arm. In making outward pressure on the upper end of the shaft the surgeon should avoid exerting the pressure directly over the end of the fragment, otherwise vessels and nerves may be forced against the sharp serrated end and injured. The effect of manipulation can, as a rule, be recognized by palpation through the axilla. With the fragments in good position there should be a disappearance of deformity. In impacted cases, however, and in those accompanied by considerable crushing of cancellous tissue, a certain amount of shortening may persist, which is impossible to correct. The deformity in fractures of the upper end of the humerus varies greatly, but if the surgeon appreciates the relative positions of the fragments and the nature of the break he will usually be able to effect a satisfactory reduction by means of extension, counter-extension and manipula- [illegible] duction of epiphyseal separations involves the same

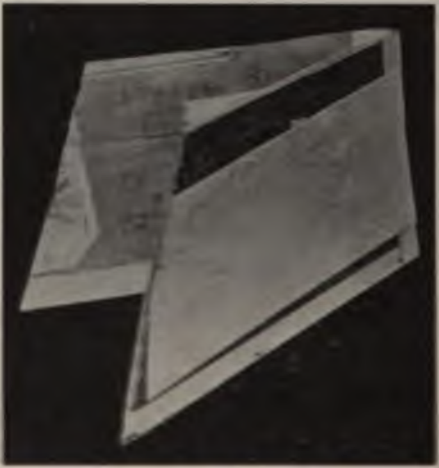


Fig. 132.—Shows cigar-box boards cut to proper size to make a diagonal axillary pad. The ends to the right have been hinged together with adhesive plaster.

[illegible] tion accomplished the question of fixation arises. [illegible] of immobilization are similar for most types of fracture of the upper end of the humerus. The most common method of immobilization, and one which will be adapted to the largest number of cases, is accomplished by means of the axillary pad and the moulded plaster shoulder cap. Various methods of preparing and applying these two elements in the dressing have been described and there is little to be said of any of them as long as they accomplish the desired result, which is fixation of the fragments in proper position without undue constriction of the arm or irritation of the skin. The details of the most satisfactory methods will be described. The key-note to the proper immobilization of the shoulder is the axillary pad.

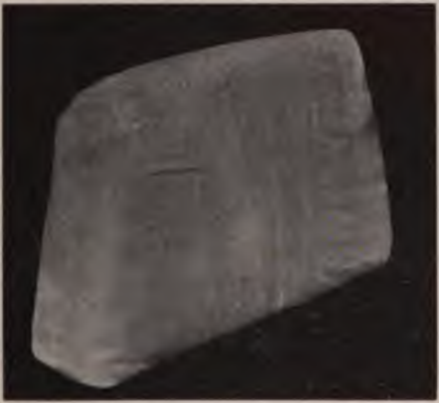


Fig. 133.—Shows axillary pad completed. Cotton has been packed in between the boards and a layer of cotton used to cover the surface. The whole is then bandaged.

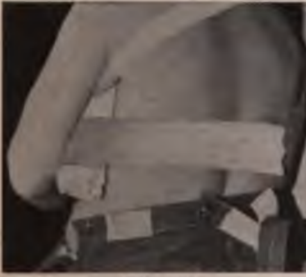


Fig. 134.

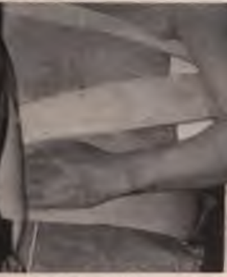


Fig. 135.

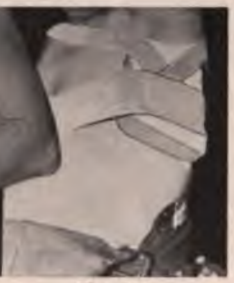


Fig. 136.

Fig. 134.—View of axillary pad from behind. Note how the pad supports the humerus down to the internal epicondyle.

Fig. 135.—Same seen from the front.

Fig. 136.—Same with arm raised. Note the oblique lower end of pad.

The axillary pad should support as much of the humerus as possible without interfering with the upper part of the forearm which is maintained in a position of semiflexion. A very satisfactory pad is made in the following manner: take two pieces of cigar-box (the lid and bottom) and cut them so that they will be a little broader than the arm and then hinge two of the ends together inside and out with adhesive as shown in Fig. 132. The boards are then placed in the opposite axilla (hinged ends up) for the purpose of measuring and marking the proper length. The pad when completed should come to about the level of the internal epicondyle posteriorly, but should be short enough anteriorly to clear the top of the semiflexed forearm. To accomplish this it will be found necessary to cut the lower ends of the boards diagonally (as shown in Fig. 132). With the boards cut to the proper size (due allowance being made for the padding) the angle is stuffed with cotton till a wedge of the proper thickness is obtained. The outside of the pad is then covered with cotton and finished by securing the padding in position with a roller bandage. The tendency for those not accustomed to constructing this dressing is to make the pad too long, and when this is done the antero-inferior angle will make the patient miserable by pressing into the upper part of the forearm, or else the pad will tend to slip backward and fail to properly support the humerus. The outer side of the pad should be evenly covered so that it will present a flat plane for the humerus to rest on. The pad is secured in position by three pieces of adhesive as shown in Figs. 135 and 136. Two of them pass over the opposite shoulder while the third encircles the body. The surgeon should see to it that the pad is properly fitted and placed before he proceeds with the making of the shoulder cap. Heavy card board (book-binders board) may be used in place of the wood, but if the material is too light the sides will tend to bow when the angle is stuffed with cotton, as described above. When this occurs the side of the pad does not present the necessary flat surface for the humerus to rest against. Light card board is entirely inadequate, and stuffing of the space between the body and trunk with folded towels is mentioned simply to be condemned. Many different methods of making an axillary pad may be followed but the above will be found as satisfactory as any.

The plaster shoulder cap is shown in Fig. 137 and is applied as follows: After reduction has been effected and the axillary pad placed in position, a pattern is cut out of sheet-cotton to properly embrace the arm and shoulder. It is best to lay the cotton on the shoulder and cut the pattern in this position. Ten or twelve layers of crinolin (or half again as many layers of gauze) are then cut according to the pattern, immersed in plaster cream, wrung out and applied to the shoulder. The sheet-cotton pattern is applied to the shoulder first and acts as the lining for the shoulder cap. The shoulder cap should be secured to the body as quickly as possible with a wide roller bandage and the patient kept perfectly quiet until the plaster has thoroughly set and dried. Later on the

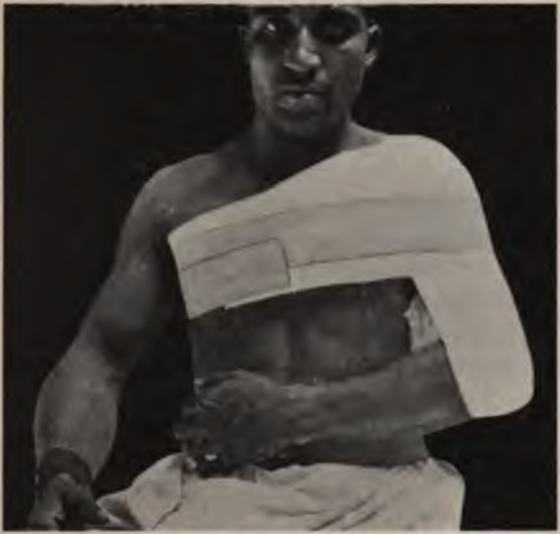


Fig. 137.—Plaster shoulder cap in position. Note the encircling strap of adhesive plaster.

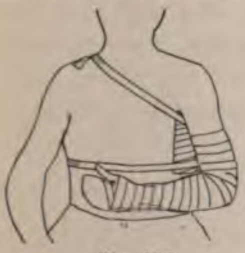


Fig. 138.

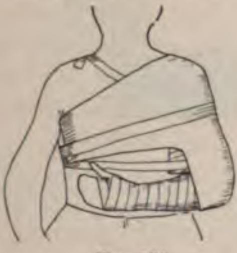


Fig. 139.

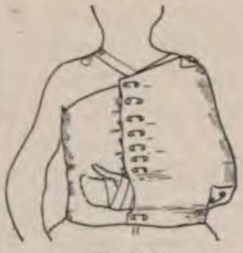


Fig. 140.

Fig. 138.—Axillary pad in position and arm bandaged.
Fig. 139.—Plaster shoulder cap in position.
Fig. 140.—Swathe encircling body and taking place of sling.

bandages may be removed and the cap secured in position by means of a body swathe or strips of adhesive plaster. Another method of securing the arm and splint to the body is by encircling both with a sufficient number of turns of plaster bandage. Wet crinolin bandage may be used instead. When this is done the trunk should be protected with sheet cotton to prevent subsequent irritation of the skin. The cap should cover the shoulder on all sides, and if additional security is desired it may be made to extend well onto the chest both in front and behind. In fractures of the upper end of the humerus it will seldom be necessary to include the elbow or forearm in the splint.

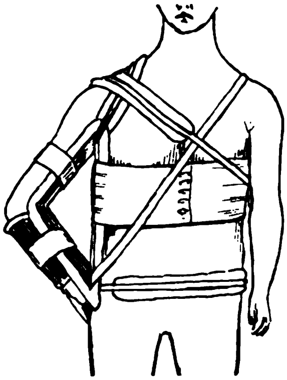


Fig. 141.

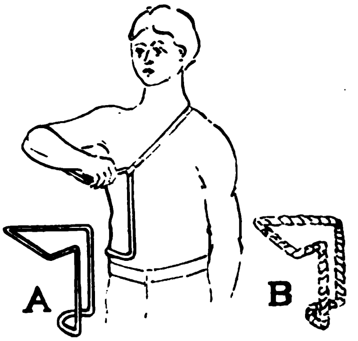


Fig. 142.

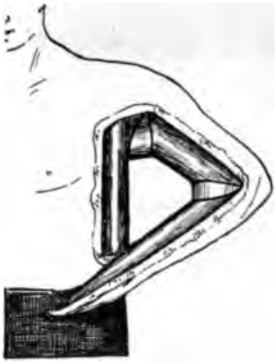


Fig. 143.

Fig. 141.—Middeldorf triangle.

Fig. 142.—The Monks triangle. *A*. shows the wire bent to proper form. *B*. shows same padded and bandaged.

Fig. 143.—Osgood-Penhallow splint for treatment of fractures of the upper end of the humerus in abduction.

It is well to snugly bandage the arm, forearm and hand with a flannel bandage before the pad and shoulder cap are applied.

A method offering very solid fixation is a plaster spica of the arm and chest though it does not permit of frequent removal or easy adjustment during the after-treatment. When the spica is employed the arm and chest should be well covered with sheet cotton, and after the dressing is finished an axillary pad should be placed in position to support the arm.

The cravat sling is called for with any of the plaster dressings about the shoulder except when the forearm is included in the splint.

It is advisable in most cases of fracture of the upper end of the humerus to employ an anesthetic during examination and reduction though it is more satisfactory to apply a plaster dressing when the patient is conscious and able to assume a convenient position. When the causative trauma is great and the ensuing traumatic reaction pronounced it is often better to treat the patient in bed during the first few days and to delay the application of a permanent dressing. During this time the arm may be secured on an axillary pad and sand bags applied to the outer side of the arm to steady the parts. The local and intermittent use of the ice cap will be of service in controlling the inflammatory reaction. In some instances the patient will be more comfortable with the arm resting on a pillow. If the suffering is great, morphine should be exhibited.

Occasionally cases are seen in which reduction cannot be maintained with the arm in a position such as assumed when the axillary pad and plaster shoulder cap are employed. Abduction, outward rotation or a forward displacement of the upper fragment may require a corresponding position of the lower fragment to keep the fractured surfaces in apposition and the fragments in alignment. To meet the requirements in such cases a number of splints have been devised. The Middledorf triangle maintains the arm in a position of partial abduction and inward rotation and is effective in some cases in preventing recurrence of deformity. (See Fig. 141.) The Monks triangle holds the arm in a nearly horizontal position with the elbow carried forward. (See Fig. 142.)

By means of a plaster cast of the upper extremity and trunk the arm may be fixed in almost any position desired. Taking everything into consideration it is probably the most satisfactory form of immobilization in instances in which the arm may not be treated at the side because of displacement of the upper fragment.

When uncomfortable and awkward positions, such as maintained by the above splints, are necessary to keep the fragments in proper relation, the question of operation should be considered. It is the author's opinion that most cases of this kind (in which reduction cannot be maintained with the arm by the side) should be operated upon, and the fragments secured in position by direct fixation.

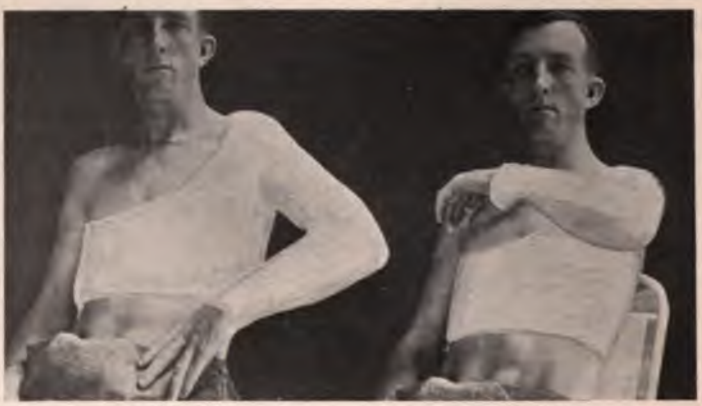


Fig. 144. Fig. 145.

Fig. 144.—Plaster cast for treatment of fracture of the upper end of the humerus in abduction. In applying the cast the humerus may be fixed in almost any position desired.

Fig. 145.—Plaster cast for treatment of fractures of the upper end of the humerus in abduction. This cast fixes the humerus in a position of greater outward rotation.

Operative Treatment.—The cases of fracture of the upper end of the humerus in which operation is indicated are numerous but the proper selection of these cases requires the most seasoned surgical judgment. Fractures in which the displacement is pronounced and not reducible by ordinary methods should be operated. Recurrence of deformity during the after-treatment is ordinarily an indication for operative intervention. Cases in which the upper fragment is abducted, rotated, or displaced forward may be treated by some form of dressing which immobilizes the arm in a position corresponding to the deformity of the upper fragment. Such dressings, however, are more or less uncomfortable and insecure and in most instances it will be advisable to expose the fragments, wire or plate them together and then fix the arm by the side with the ordinary axillary pad and shoulder cap dressing.

The fragments are to be exposed through a vertical incision on the anterior or external aspect of the shoulder. The circumflex nerve will be found winding around the surgical neck of the bone and should be avoided. It is best to expose the fragments by dull dissection in the deeper part of the wound until the nerve has been located and isolated. With the fragments exposed the needs of the case are determined and the details of the operation from this time on will vary accordingly. Reduction of deformity is performed by means of extension, counter-extension and manipulation, and is rendered easier by direct manipulation of the fragments when necessary. The fact that the fragments may be directly inspected during manipulation is of the greatest service in correcting the displacement. If a firm engagement between the fragments can be obtained by manipulation the wound may be closed and the operation concluded; if, however, there is a tendency to redisplacement some form of internal fixation must be employed. A consideration of the illustration on page 83 will show that the structure of the bone above the surgical neck is composed of a wide-meshed cancellous tissue covered only by a very thin layer of compact bone, and it is in this formation that very little dependence can be placed on nails, pegs, screws, etc. Silver wire will afford the most trustworthy fixation and should be given the preference in the region of the anatomical neck. It is frequently the case that a simple loop of wire passing through the outer side of the fracture as shown in Fig. 98 will secure a safe and accurate apposition. The Lane plate has been used in the region of the greater tuberosity though it is not reasonable to expect security from it when the screws holding it are not placed in a fairly heavy layer of compact tissue. Accordingly it is of greater value a little lower in the bone. It is sometimes necessary to excise the head of the bone because of extensive comminution, or in old cases because of non-union. It is well to remember that the head very rarely suffers necrosis following separation from the shaft. Attempts to save the head are usually successful with accurate apposition and the proper degree of fixation. Reduction and fixation of fractures of the surgical neck are not as a rule attended by great difficulty unless there is extensive comminution of the upper fragment. When the upper fragment is broken into many pieces it may be impossible to completely restore the bone to its original lines. A wire encircling the surgical neck, with notches in the bone to prevent its slipping downward, may be of great value in longitudinal splitting. It should be so placed as not to interfere with the long head of the biceps. Isolated fractures of the tuberosities are rare injuries. Little difficulty should be experienced in returning the detached tuberosity to its original position and securing it in place.

In epiphyseal separations reduction of the deformity will usually be all that is required, as displacement is prevented by the projection of the center of the diaphysis upward into the epiphysis. (See Figs. 110 and 111.) Suture of the periosteum on the outer side of the bone will increase the security of reduction. If a tendency to recurrence of deformity is present absorbable suture material may be passed through drill holes in the bone. Non-absorbable suture material should not be used across an epiphyseal cartilage.

It is well to insert a small drain of silkworm gut before the wound is closed to relieve the joint of blood and serum; this drain should be removed in from twenty-four to forty-eight hours.

After-Treatment.- In the average child or young adult union may be expected at the end of four weeks, while a middle-aged person should be allowed from five to six weeks for callous formation. In the aged union may be much delayed. The acute swelling about the joint will usually have subsided at the end of ten days or two weeks. During the time the shoulder is decreasing in size the padding on the inside of the shoulder cap will require frequent changing and adjustment so that the cap may properly fit the shoulder. If the swelling has been great it may be necessary to apply a new cap when the shoulder approaches the normal in size.

The case should be seen daily for the first ten days, after which every two or three days will be sufficient. The axillary pad sometimes becomes loosened and is likely to slip downward or backward, and if not replaced may be responsible for a change in the position of the fragments. Gentle passive motion should be begun at the end of two or two and a half weeks in uncomplicated cases. Passive motion should at all times be gentle, and the production of pain must represent the limit of motion. The splints should be removed at the end of four to six weeks, according to the age and condition of the patient, and the arm carried in a sling for another ten days. The patient should be especially cautioned not to submit the arm to any great strain for the first two months following the removal of splints. Extreme abduction is the last motion to be regained by the patient and in elderly persons it is not infrequently lost permanently. Should paralysis of any of the nerves supervene during the after-treatment (as evidenced by wrist drop or contractures) we should lose no time in exploring the nerve involved where it crosses the line of fracture. The circumflex is the single nerve most frequently involved in fractures of the upper end of the humerus. End results following operations on the nerves cannot be expected inside of four to six months at the earliest. Atrophy of the deltoid not infrequently occurs from disuse alone without injury to the circumflex. This condition is not in itself a cause for anxiety since the muscle will regain its size and tone with use.

Following reduction of an epiphyseal separation fixation should be maintained for three or four weeks.

Early passive motion is of the greatest value in fractures of the upper end of the humerus. Restricted motion in the shoulder is often the result of a too prolonged immobilization. If joint adhesions are present after union is firm they may be forcibly broken up under anesthesia, but before this is attempted the surgeon should be positive that the callus is firm enough to stand the manipulation without refracture.

Prognosis.—The outlook in fractures of the upper end of the humerus will depend on the severity of the break and the age and condition of the patient. A fair degree of reduction will usually be followed by perfect recovery in youthful subjects. The older the patient the greater the probability of incomplete restoration of function. In the aged non-union may follow in spite of the most perfect treatment. In patients past middle life there is often slight restriction of motion and pain about the joint occurring with changes in the weather. The range of motion may be free and yet the shoulder weak.

Loss of growth following epiphyseal separation is an extremely rare condition and need not be expected if anything like a fair reduction has been accomplished following the accident. Moderate deformity, if present, will decrease as the years go by.

CHAPTER VIII.

FRACTURES OF THE SHAFT OF THE HUMERUS.

Surgical Anatomy. To appreciate the deformities accompanying fractures of the shaft of the humerus the attachments and directions of pull of the different muscles should be known. (See Figs. 146 and 147.) When the line of fracture is through the insertions of the pectoralis major, latissimus dorsi and teres major the deformity is usually slight and consists of an inward displacement of both fragments so that the deformity is, as a rule, purely angular. When the fracture is below the insertions of these muscles, but above the deltoid eminence, the lower fragment will usually be displaced upward and outward by the deltoid, while the upper fragment is drawn inward by the pull of the pectoralis, teres, and latissimus. When the fracture is below the insertion of the deltoid the upper fragment will be displaced outward. In any fracture of the humeral shaft the serrated ends may be firmly enough engaged to prevent lateral and overriding displacement, and under such circumstances the deformity is purely angular if present at all. Shortening of the arm is caused for the most part by the action of the biceps and triceps.

The humerus has a wider range of motion than any other bone in the body and the varieties of strain to which it may be subjected are great. Accordingly we may see any type of fracture common to long bones. The shaft of the humerus is composed of a heavy tube of compact tissue which grows larger in circumference and lighter in structure as the extremities are approached.

The musculo-spiral nerve supplying the extensors and supinators descends obliquely, from above, downward and outward, between the two humeral heads of the triceps. It lies in contact with the bone in the musculo-spiral groove and in this position is particularly exposed to injury in fractures of the humeral shaft. It may be injured by direct contusion and laceration at the time of the accident or it may be subsequently caught and compressed by the callus.

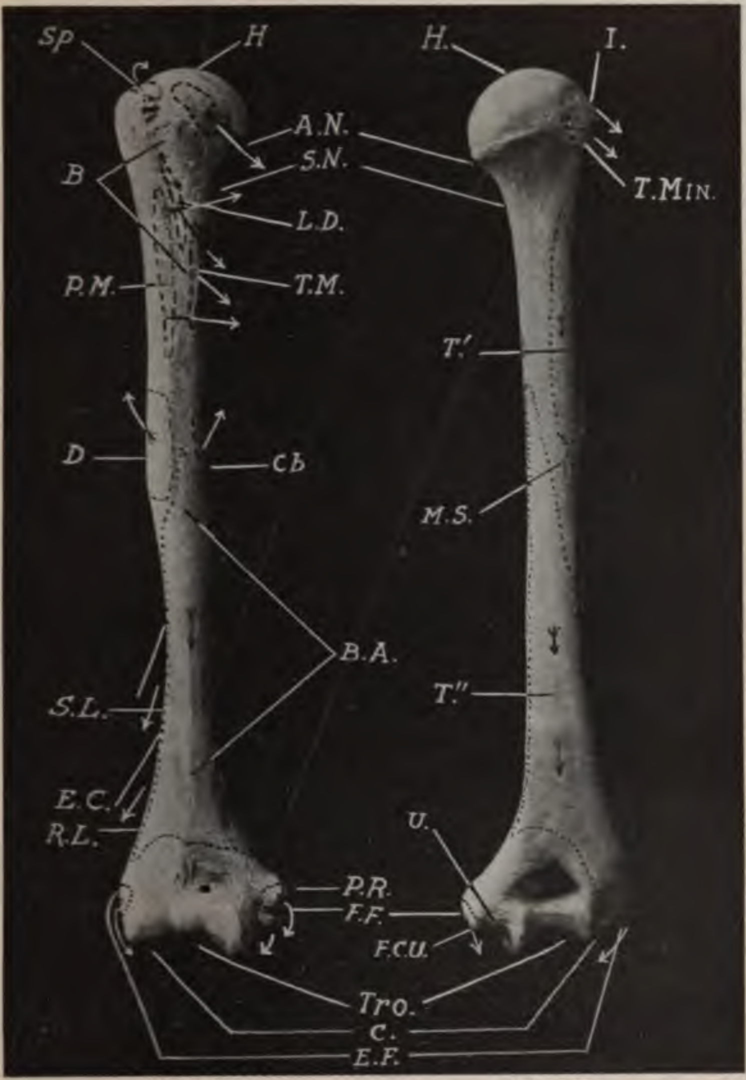


Fig. 146. Fig. 147.

Figs. 146 and 147.—Views of the anterior and posterior surfaces of the right humerus. The arrows indicate the pull of the attached muscles.

H., Head of the humerus; *A.N.*, Anatomical neck; *S.N.*, Surgical neck; *L.D.*, Attachment of the latissimus dorsi; *T.M.*, Attachment of the tēres major; *Cb.*, Coracobrachialis; *T′.*, Outer head of the triceps; *T″.*, Inner head of the triceps; *M.S.*, Musculospiral groove; *B.*, Bicipital groove; *P.M.*, Insertion of the pectoralis major; *I.*, Infraspinatus; *T.Min.*, Teres minor; *D.*, Insertion of the deltoid; *S.L.*, Supinator longus; *E.C.R.L.*, Extensor carpi radialis longior; *U.*, Groove for ulnar nerve; *P.R.*, Pronator radii teres; *F.F.*, Flexors of the forearm; *F.C.U.*, Flexor carpi ulnaris; *Tro.*, Trochlear surface of humerus; *C.*, Capitellum; *E.F.*, Extensors of the forearm.

Inward displacement of one or both of the fragments may be the cause of laceration or compression of the brachial artery which lies to the inner side of the shaft.

Green-stick fractures are seldom seen and multiple breaks are uncommon. Direct violence is usually responsible for fractures of the transverse type; spiral and oblique fractures are the result of twisting strains. Muscular action is especially productive of fracture of the humeral shaft, and in some cases (particularly in elderly persons) the degree of causative trauma may be disproportionately small. Impaction of the fragments is almost never seen.

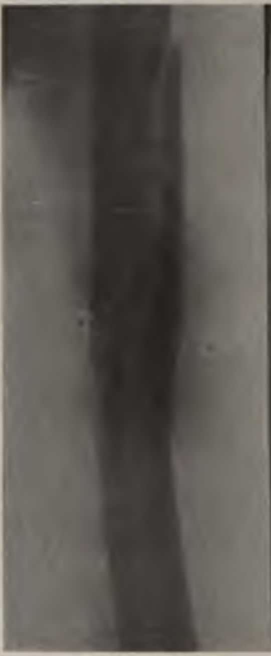


Fig. 148.

Fig. 149.

Fig. 148.—Spiral, comminuted fracture of humeral shaft.
Fig. 149.—Fracture of shaft with overriding and rotary deformity.

The most common seat of fracture is at or a little below the middle of the shaft.

Symptoms.—There is pain, loss of function, crepitus, abnormal mobility and varying deformity. Swelling usually develops rapidly and ecchymosis is seen within the first day. The relative position of the fragments varies with the level of the break and has been

explained under "Surgical Anatomy," page 108. The deformity is almost always sufficiently pronounced to be recognized by inspection alone.

The patient supports the injured member with the opposite hand in a manner which is characteristic. (See Diagnosis under "Dislocations of the Shoulder," page 65.)

The patient is able to move the hand and fingers, and the reflexes below the site of the fracture are intact unless some of the nerves have been injured.

Fig. 150.

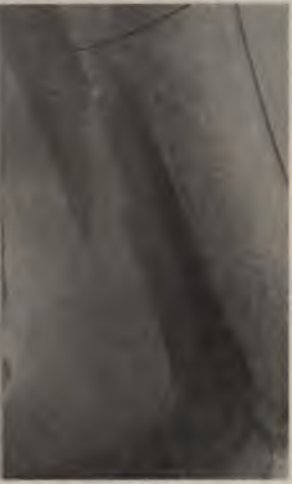


Fig. 151.

Fig. 150.—Multiple spiral fracture of humeral shaft with pronounced deformity.

Fig. 151.—Oblique fracture of humeral shaft with separation of fragments. (Taken through heavy fibre splint.)

A weakening or absence of the radial pulse indicates laceration or compression of the brachial artery.[1]

The development of a hematoma may sometimes be recognized in the arm following tearing of the artery.

Diagnosis.—Fractures of the humeral shaft are, as a rule, recognized without difficulty. The deformity is usually so pronounced that the diagnosis can be made by inspection alone. As soon as the arm is manipulated the point of abnormal mobility is apparent in almost all cases. Fracture of the shaft is a common fracture and is not infrequently associated with injuries to neigh-

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[1] A thrombosis of the brachial artery may be slow in forming and when it is the alteration in the pulse will be delayed.

Treatment.—The treatment will vary according to the location of the fracture and the direction and degree of displacement. It is best in most instances to reduce the deformity under anesthesia. Traction, counter-traction and manipulation will suffice in many cases to bring the fragments into proper apposition and alignment. In transverse fractures with overriding (especially when the ends are deeply serrated), reduction can best be effected by producing angular deformity and manipulating the fragments in this position until the serrated ends have been engaged. The bone is then straightened and appropriate dressings applied. In producing angular deformity for the purpose of engaging the ends, the arm should be bowed outward, to avoid stretching of the artery and nerves which lie on the inner side of the shaft. It is usually not difficult to effect reduction of a spiral or oblique fracture but it is frequently impossible to prevent recurrence of deformity in breaks of these types without resorting to internal fixation. Outward rotation of the upper fragment in a spiral or oblique fracture may act as a serious obstacle to reduction.

Fractures of the upper third of the shaft are to be treated with dressings such as already described in the Treatment of "Fractures of the Upper End of the Humerus" (page 101), namely axillary pad, plaster shoulder cap, cravat sling, body swathe, etc. There is this to be said, however, in regard to the shoulder cap; the lower the fracture the greater the need of extending this dressing downward to include the forearm. Coaptation splints are often used in fractures of the middle of the shaft though they may well be dispensed with, as a permanent dressing, in favor of a properly applied shoulder cap. It is a common practice to treat the condition during the onset and subsidence of swelling with the axillary pad, coaptation splints, body swathe and sling. Later on the coaptation splints are replaced by the plaster shoulder cap as a permanent dressing. In fractures of the lower third the elbow should be solidly immobilized. The axillary pad is not appropriate, and carrying the arm in a sling is entirely inadequate to secure fixation if the fracture is near the elbow. A most satisfactory method of fixation in this portion of the shaft is that shown in Fig. 215 and is described below.

The following may be considered a fair example of the treatment of a fracture of the shaft of the humerus shortly following the accident. The patient is placed in as comfortable a position as possible, preferably the recumbent, and an examination made of the parts, to determine as accurately as may be the exact nature and position of the fracture. The examination is more satisfactorily carried out under anesthesia. It should be remembered that the less the parts are manipulated the better it will be for the soft tissues surrounding the jagged ends of the fragments. After the fracture has been diagnosed the proper dressings should be prepared so that everything may be in readiness as soon as reduction has been effected.

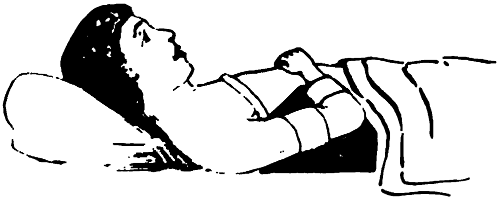

Fig. 154. Stromeyer cushion.

It is needless to add that the surgeon should, at this time, satisfy himself as to which form of dressing will best meet the requirements of the case in hand. In instances in which the trauma has been great it is often best to leave the parts undisturbed and to treat the patient in the recumbent position for a week or ten days until the acute inflammatory reaction has subsided. During this time the arm may be supported on a pillow and the ice cap used to control the reaction. The Stromeyer cushion, or one of its modifications, may be used to advantage. If, on the other hand, it seems advisable to immobilize the arm at once the following details may be observed. The arm and side of the chest are sponged, dried and dusted with talcum powder, special attention being paid to the axilla. An axillary pad is then constructed as described on page

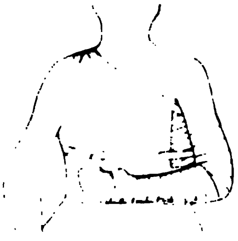

Fig. 155.

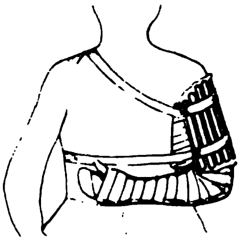

Fig. 156.

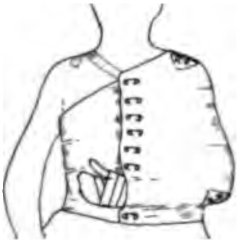

Fig. 157.

Fig. 155. Arm bandaged and axillary pad in position.
Fig. 156. Coaptation splints applied.
Fig. 157. Swathe encircling body and acting as sling. (See Figs. 132 to 142 inclusive.)

100. Coaptation splints are next made by placing thin wood on adhesive plaster (cigar-box wood is excellent) and splitting the wood with a knife. The splint should include as much of the arm, from the shoulder to the elbow, as possible without pressing into the axillary fold above, or the top of the flexed forearm below. The portion of the coaptation splint on the outer side of the arm may be longer than that on the inner side. A body swathe is next prepared of two or three thicknesses of heavy muslin. It should be long enough to encircle the body and injured member and broad enough to extend from the top of the shoulder to a point below the elbow. A cravat sling is then prepared and the necessary materials are ready.

The axillary pad is placed in position and secured with adhesive plaster, after which the surgeon is ready to attempt reduction. The injured member is grasped above and below the seat of fracture, and the fragments gently but firmly manipulated until the senses of sight and touch pronounce the position satisfactory. The coaptation splint is then well padded, applied and secured in position with adhesive plaster. The arm is then firmly placed against the axillary pad and secured by the body swathe. The cravat sling completes the dressing, or in lieu of the sling the forearm may be included in the swathe, allowing the hand to emerge between the layers where they are pinned together. This form of dressing is least likely to strangulate the arm during the first week of treatment when the traumatic reaction and swelling are in progress.

A very satisfactory method of fixation in fractures below the middle of the shaft is one in which internal and external plaster splints are used, as shown in Fig. 215. These splints are made of plain gauze (from fifteen to twenty ply) and should be reinforced at the elbow by the insertion of additional layers of gauze between the layers of the splint. The external splint extends from a point well up on the shoulder, along the back of the arm and forearm to the wrist, while the internal splint extends from just below the axillary fold to the wrist on the anterior aspect of the upper extremity. They are applied to the injured member while wet and rapidly secured in position with a roller bandage. The surgeon holds the fragments in proper reduction until the plaster has set. Specific instructions should be given to the patient and his attendants not to allow the splints to be covered with clothing or bed covers for at least twenty-four hours so the plaster may become thoroughly dried out. One or two folded towels should be placed between the arm and the body, and a light swathe used encircling the chest and injured member. The following day the splints should be removed one at a time, lined with a layer of sheet cotton and replaced. The splints should then be secured in position by means of strips of adhesive plaster encircling the arm. The body swathe may be used in securing the arm by the side, or strips of adhesive may be used for this purpose. Sufficient padding should be placed in the external splint in the region of the olecranon to avoid chafing and discomfort. This dressing is quite secure but requires careful watching to avoid strangulation when swelling sets in. It is of particular advantage in compound fractures of the lower end of the humeral shaft since the arm may be permanently secured to one splint while the other is removed daily for inspection and dressing of the wound.

After the arm is immobilized (whatever the type of dressing may be) an X-ray should be taken, when possible, to verify the diagnosis and to determine the accuracy of reduction.

When overriding deformity cannot be corrected by solid engagement of the fractured ends weights may be attached to the elbow to control the action of the biceps and triceps. (Fig. 214.)

The use of extension may be indicated in some cases if employed in the recumbent position, but as an ambulatory method it is, in the author's opinion, entirely too haphazard and untrustworthy to be relied upon, notwithstanding statements to the contrary. It may be stated as a rule that fractures of the shaft requiring permanent extension to maintain reduction should be submitted to operation, and the fragments wired or plated in position. If ambulatory extension is employed, and fails, we have a condition of deformity which we know only too well might have been prevented by proper operative intervention.

Operative Treatment.—Fractures of the humeral shaft are frequently of the oblique or spiral type and accurate reduction is often impossible without open incision and internal fixation. The frequency with which one sees deformity following fractures of the humeral shaft treated by non-operative methods, indicates the value of open incision in the treatment of breaks in this region.

It is usually best to approach the bone through an external longitudinal incision of sufficient length to allow free access for manipulation and reduction. The greatest care should be used to avoid injury to the musculo-spiral nerve in making the incision and in accomplishing reduction and fixation. Destruction of the function of this nerve will be more disastrous to the patient than non-union of the fragments or union with deformity. It should be kept in mind therefore that it is possible for the surgeon to produce an injury which is far worse than the condition which he is operating to correct; accordingly the course of the musculo-spiral nerve should be thoroughly appreciated before operation in this region is attempted.

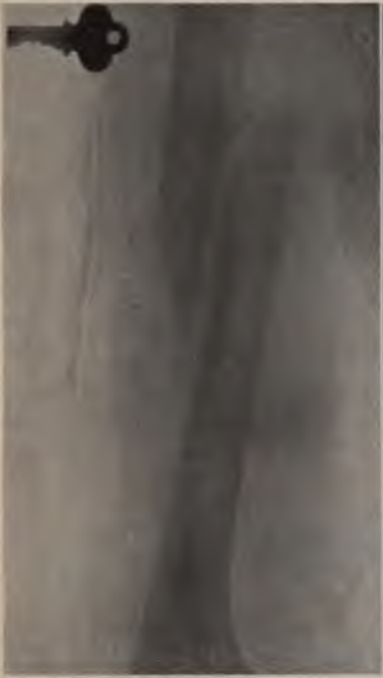

Fig. 158.

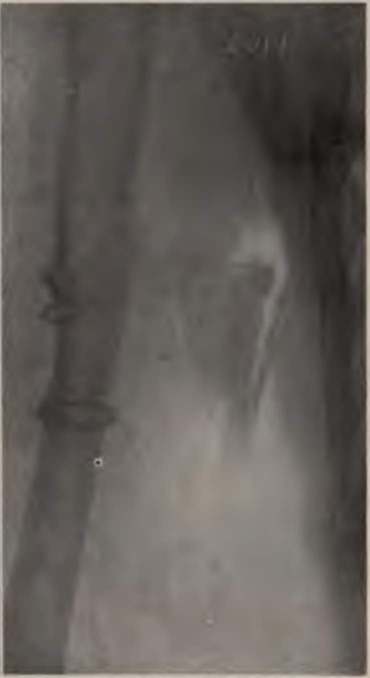

Fig. 159.

Fig. 158.—Röntgenogram of spiral fracture of humerus after two attempts at reduction. Rotary and lateral deformity present.

Fig. 159.—Same case after operation, showing fragments held in reduction by two wires. The lower wire encircles the bone while the other, at a higher level, penetrates the shaft and secures leverage for the lower wire.

After the fragments have been exposed the nature of the fracture is accurately ascertained, reduction accomplished and the best method of fixation determined. Each case must be considered by itself, and the nature of the deformity fully appreciated before

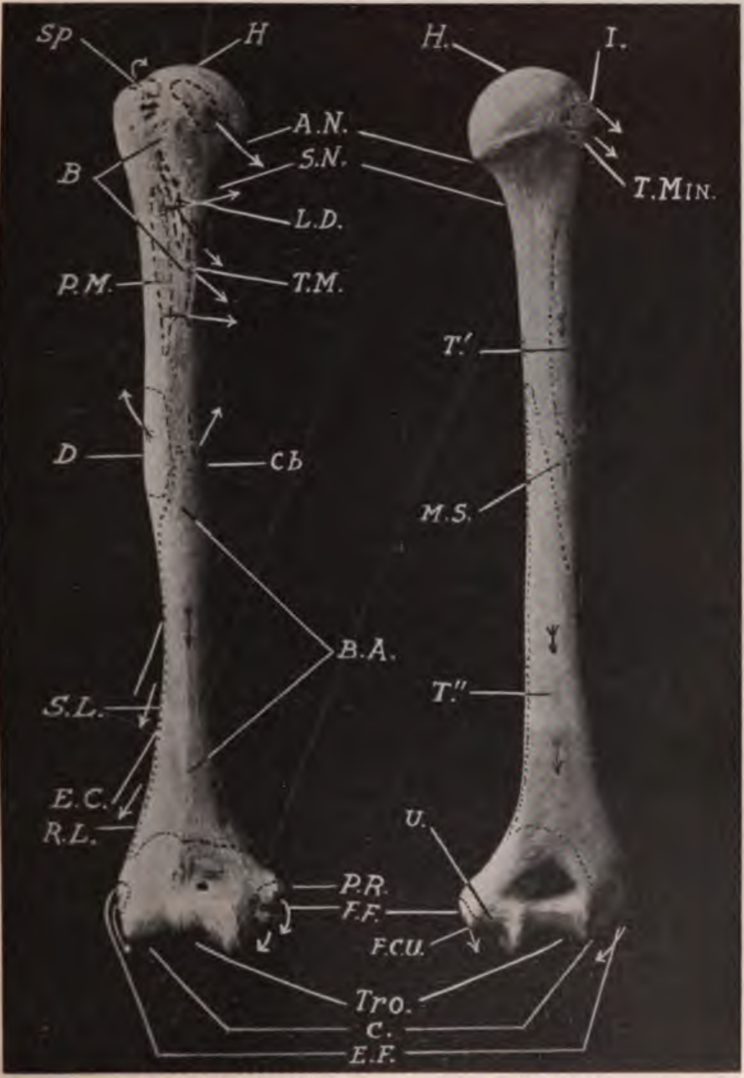

Fig. 146. Fig. 147.

Figs. 146 and 147.—Views of the anterior and posterior surfaces of the right humerus. The arrows indicate the pull of the attached muscles.

H., Head of the humerus; *A.N.*, Anatomical neck; *S.N.*, Surgical neck; *L.D.*, Attachment of the latissimus dorsi; *T.M.*, Attachment of the téres major; *Cb.*, Coracobrachialis; *T'.*, Outer head of the triceps; *T''.*, Inner head of the triceps; *M.S.*, Musculospiral groove; *B.*, Bicipital groove; *P.M.*, Insertion of the pectoralis major; *I.*, Infraspinatus; *T.Min.*, Teres minor; *D.*, Insertion of the deltoid; *S.L.*, Supinator longus; *E.C.R.L.*, Extensor carpi radialis longior; *U.*, Groove for ulnar nerve; *P.R.*, Pronator radii teres; *F.F.*, Flexors of the forearm; *F.C.U.*, Flexor carpi ulnaris; *Tro.*, Trochlear surface of humerus; *C.*, Capitellum; *E.F.*, Extensors of the forearm.

Inward displacement of one or both of the fragments may be the cause of laceration or compression of the brachial artery which lies to the inner side of the shaft.

Green-stick fractures are seldom seen and multiple breaks are uncommon. Direct violence is usually responsible for fractures of the transverse type; spiral and oblique fractures are the result of twisting strains. Muscular action is especially productive of fracture of the humeral shaft, and in some cases (particularly in elderly persons) the degree of causative trauma may be disproportionately small. Impaction of the fragments is almost never seen.

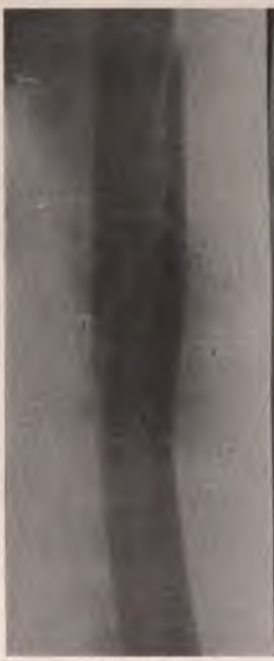

Fig. 148.

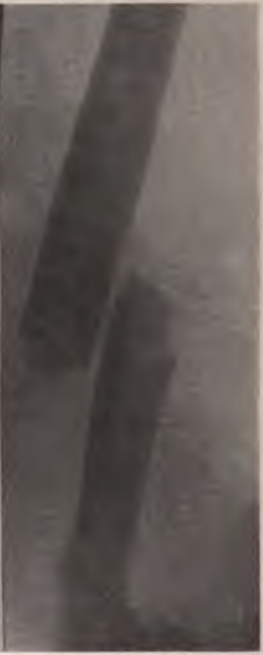

Fig. 149.

Fig. 148.—Spiral, comminuted fracture of humeral shaft.
Fig. 149.—Fracture of shaft with overriding and rotary deformity.

The most common seat of fracture is at or a little below the middle of the shaft.

Symptoms.—There is pain, loss of function, crepitus, abnormal mobility and varying deformity. Swelling usually develops rapidly and ecchymosis is seen within the first day. The relative position of the fragments varies with the level of the break and has been

explained under "Surgical Anatomy," page 108. The deformity is almost always sufficiently pronounced to be recognized by inspection alone.

The patient supports the injured member with the opposite hand in a manner which is characteristic. (See Diagnosis under "Dislocations of the Shoulder," page 65.)

The patient is able to move the hand and fingers, and the reflexes below the site of the fracture are intact unless some of the nerves have been injured.

Fig. 150.

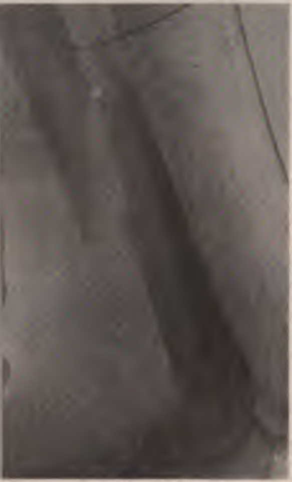

Fig. 151.

Fig. 150.—Multiple spiral fracture of humeral shaft with pronounced deformity.

Fig. 151.—Oblique fracture of humeral shaft with separation of fragments. (Taken through heavy fibre splint.)

A weakening or absence of the radial pulse indicates laceration or compression of the brachial artery.[1]

The development of a hematoma may sometimes be recognized in the arm following tearing of the artery.

Diagnosis.—Fractures of the humeral shaft are, as a rule, recognized without difficulty. The deformity is usually so pronounced that the diagnosis can be made by inspection alone. As soon as the arm is manipulated the point of abnormal mobility is apparent in almost all cases. Fracture of the shaft is a common fracture and is not infrequently associated with injuries to neighbandages may be removed and the cap secured in position by means of a body swathe or strips of adhesive plaster. Another method of securing the arm and splint to the body is by encircling both with a sufficient number of turns of plaster bandage. Wet crinolin bandage may be used instead. When this is done the trunk should be protected with sheet cotton to prevent subsequent irritation of the skin. The cap should cover the shoulder on all sides, and if additional security is desired it may be made to extend well onto the chest both in front and behind. In fractures of the upper end of the humerus it will seldom be necessary to include the elbow or forearm in the splint.

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[1] A thrombosis of the brachial artery may be slow in forming and when it is the alteration in the pulse will be delayed.

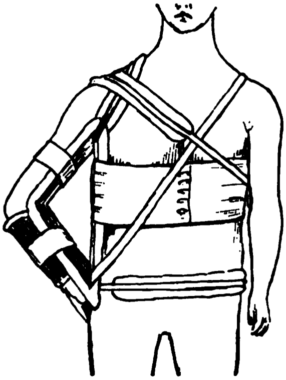

Fig. 141.

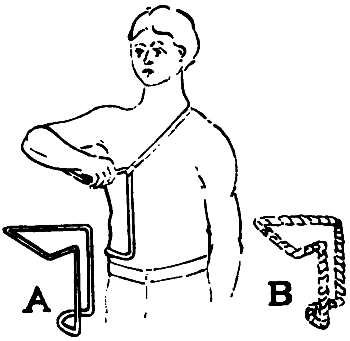

Fig. 142.

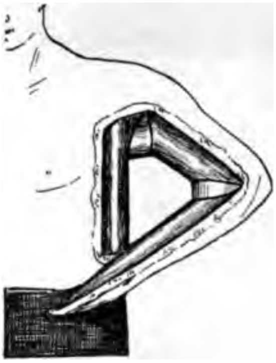

Fig. 143.

Fig. 141.—Middeldorf triangle.

Fig. 142.—The Monks triangle. *A*. shows the wire bent to proper form. *B*. shows same padded and bandaged.

Fig. 143.—Osgood-Penhallow splint for treatment of fractures of the upper end of the humerus in abduction.

It is well to snugly bandage the arm, forearm and hand with a flannel bandage before the pad and shoulder cap are applied.

A method offering very solid fixation is a plaster spica of the arm and chest though it does not permit of frequent removal or easy adjustment during the after-treatment. When the spica is employed the arm and chest should be well covered with sheet cotton, and after the dressing is finished an axillary pad should be placed in position to support the arm.

The cravat sling is called for with any of the plaster dressings about the shoulder except when the forearm is included in the splint.

It is advisable in most cases of fracture of the upper end of the humerus to employ an anesthetic during examination and reduction though it is more satisfactory to apply a plaster dressing when the patient is conscious and able to assume a convenient position. When the causative trauma is great and the ensuing traumatic reaction pronounced it is often better to treat the patient in bed during the first few days and to delay the application of a permanent dressing. During this time the arm may be secured on an axillary pad and sand bags applied to the outer side of the arm to steady the parts. The local and intermittent use of the ice cap will be of service in controlling the inflammatory reaction. In some instances the patient will be more comfortable with the arm resting on a pillow. If the suffering is great, morphine should be exhibited.

Occasionally cases are seen in which reduction cannot be maintained with the arm in a position such as assumed when the axillary pad and plaster shoulder cap are employed. Abduction, outward rotation or a forward displacement of the upper fragment may require a corresponding position of the lower fragment to keep the fractured surfaces in apposition and the fragments in alignment. To meet the requirements in such cases a number of splints have been devised. The Middledorf triangle maintains the arm in a position of partial abduction and inward rotation and is effective in some cases in preventing recurrence of deformity. (See Fig. 141.) The Monks triangle holds the arm in a nearly horizontal position with the elbow carried forward. (See Fig. 142.)

By means of a plaster cast of the upper extremity and trunk the arm may be fixed in almost any position desired. Taking everything into consideration it is probably the most satisfactory form of immobilization in instances in which the arm may not be treated at the side because of displacement of the upper fragment.

When uncomfortable and awkward positions, such as maintained by the above splints, are necessary to keep the fragments in proper relation, the question of operation should be considered. It is the author's opinion that most cases of this kind (in which reduction cannot be maintained with the arm by the side) should be operated upon, and the fragments secured in position by direct fixation.

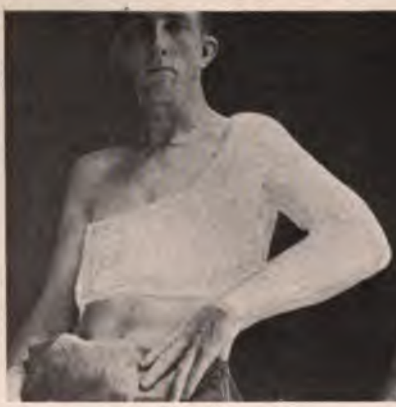

Fig. 144.

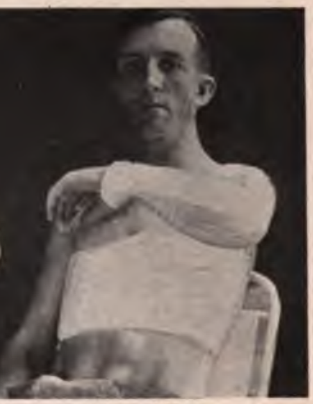

Fig. 145.

Fig. 144.—Plaster cast for treatment of fracture of the upper end of the humerus in abduction. In applying the cast the humerus may be fixed in almost any position desired.

Fig. 145.—Plaster cast for treatment of fractures of the upper end of the humerus in abduction. This cast fixes the humerus in a position of greater outward rotation.

Operative Treatment.—The cases of fracture of the upper end of the humerus in which operation is indicated are numerous but the proper selection of these cases requires the most seasoned surgical judgment. Fractures in which the displacement is pronounced and not reducible by ordinary methods should be operated. Recurrence of deformity during the after-treatment is ordinarily an indication for operative intervention. Cases in which the upper fragment is abducted, rotated, or displaced forward may be treated by some form of dressing which immobilizes the arm in a position corresponding to the deformity of the upper fragment. Such dressings, however, are more or less uncomfortable and insecure and in most instances it will be advisable to expose the fragments, wire or plate them together and then fix the arm by the side with the ordinary axillary pad and shoulder cap dressing.

The fragments are to be exposed through a vertical incision on the anterior or external aspect of the shoulder. The circumflex nerve will be found winding around the surgical neck of the bone and should be avoided. It is best to expose the fragments by dull dissection in the deeper part of the wound until the nerve has been located and isolated. With the fragments exposed the needs of the case are determined and the details of the operation from this time on will vary accordingly. Reduction of deformity is performed by means of extension, counter-extension and manipulation, and is rendered easier by direct manipulation of the fragments when necessary. The fact that the fragments may be directly inspected during manipulation is of the greatest service in correcting the displacement. If a firm engagement between the fragments can be obtained by manipulation the wound may be closed and the operation concluded; if, however, there is a tendency to redisplacement some form of internal fixation must be employed. A consideration of the illustration on page 83 will show that the structure of the bone above the surgical neck is composed of a wide-meshed cancellous tissue covered only by a very thin layer of compact bone, and it is in this formation that very little dependence can be placed on nails, pegs, screws, etc. Silver wire will afford the most trustworthy fixation and should be given the preference in the region of the anatomical neck. It is frequently the case that a simple loop of wire passing through the outer side of the fracture as shown in Fig. 98 will secure a safe and accurate apposition. The Lane plate has been used in the region of the greater tuberosity though it is not reasonable to expect security from it when the screws holding it are not placed in a fairly heavy layer of compact tissue. Accordingly it is of greater value a little lower in the bone. It is sometimes necessary to excise the head of the bone because of extensive comminution, or in old cases because of non-union. It is well to remember that the head very rarely suffers necrosis following separation from the shaft. Attempts to save the head are usually successful with accurate apposition and the proper degree of fixation. Reduction and fixation of fractures of the surgical neck are not as a rule attended by great difficulty unless there is extensive comminution of the upper fragment. When the upper fragment is broken into many pieces it may be impossible to completely restore the bone to its original lines. A wire encircling the surgical neck, with notches in the bone to prevent its slipping downward, may be of great value in longitudinal splitting. It should be so placed as not to interfere with the long head of the biceps. Isolated fractures of the tuberosities are rare injuries. Little difficulty should be experienced in returning the detached tuberosity to its original position and securing it in place.

In epiphyseal separations reduction of the deformity will usually be all that is required, as displacement is prevented by the projection of the center of the diaphysis upward into the epiphysis. (See Figs. 110 and 111.) Suture of the periosteum on the outer side of the bone will increase the security of reduction. If a tendency to recurrence of deformity is present absorbable suture material may be passed through drill holes in the bone. Nonabsorbable suture material should not be used across an epiphyseal cartilage.

It is well to insert a small drain of silkworm gut before the wound is closed to relieve the joint of blood and serum; this drain should be removed in from twenty-four to forty-eight hours.

After-Treatment.—In the average child or young adult union may be expected at the end of four weeks, while a middle-aged person should be allowed from five to six weeks for callous formation. In the aged union may be much delayed. The acute swelling about the joint will usually have subsided at the end of ten days or two weeks. During the time the shoulder is decreasing in size the padding on the inside of the shoulder cap will require frequent changing and adjustment so that the cap may properly fit the shoulder. If the swelling has been great it may be necessary to apply a new cap when the shoulder approaches the normal in size.

The case should be seen daily for the first ten days, after which every two or three days will be sufficient. The axillary pad sometimes becomes loosened and is likely to slip downward or backward, and if not replaced may be responsible for a change in the position of the fragments. Gentle passive motion should be begun at the end of two or two and a half weeks in uncomplicated cases. Passive motion should at all times be gentle, and the production of pain must represent the limit of motion. The splints should be removed at the end of four to six weeks, according to the age and condition of the patient, and the arm carried in a sling for another ten days. The patient should be especially cautioned not to submit the arm to any great strain for the first two months following the removal of splints. Extreme abduction is the last motion to be regained by the patient and in elderly persons it is not infrequently lost permanently. Should paralysis of any of the nerves supervene during the after-treatment (as evidenced by wrist drop or contractures) we should lose no time in exploring the nerve involved where it crosses the line of fracture. The circumflex is the single nerve most frequently involved in fractures of the upper end of the humerus. End results following operations on the nerves cannot be expected inside of four to six months at the earliest. Atrophy of the deltoid not infrequently occurs from disuse alone without injury to the circumflex. This condition is not in itself a cause for anxiety since the muscle will regain its size and tone with use.

Following reduction of an epiphyseal separation fixation should be maintained for three or four weeks.

Early passive motion is of the greatest value in fractures of the upper end of the humerus. Restricted motion in the shoulder is often the result of a too prolonged immobilization. If joint adhesions are present after union is firm they may be forcibly broken up under anesthesia, but before this is attempted the surgeon should be positive that the callus is firm enough to stand the manipulation without refracture.

Prognosis.—The outlook in fractures of the upper end of the humerus will depend on the severity of the break and the age and condition of the patient. A fair degree of reduction will usually be followed by perfect recovery in youthful subjects. The older the patient the greater the probability of incomplete restoration of function. In the aged non-union may follow in spite of the most perfect treatment. In patients past middle life there is often slight restriction of motion and pain about the joint occurring with changes in the weather. The range of motion may be free and yet the shoulder weak.

Loss of growth following epiphyseal separation is an extremely rare condition and need not be expected if anything like a fair reduction has been accomplished following the accident. Moderate deformity, if present, will decrease as the years go by.

CHAPTER VIII.

FRACTURES OF THE SHAFT OF THE HUMERUS.

Surgical Anatomy.—To appreciate the deformities accompanying fractures of the shaft of the humerus the attachments and directions of pull of the different muscles should be known. (See Figs. 146 and 147.) When the line of fracture is through the insertions of the pectoralis major, latissimus dorsi and teres major the deformity is usually slight and consists of an inward displacement of both fragments so that the deformity is, as a rule, purely angular. When the fracture is below the insertions of these muscles, but above the deltoid eminence, the lower fragment will usually be displaced upward and outward by the deltoid, while the upper fragment is drawn inward by the pull of the pectoralis, teres, and latissimus. When the fracture is below the insertion of the deltoid the upper fragment will be displaced outward. In any fracture of the humeral shaft the serrated ends may be firmly enough engaged to prevent lateral and overriding displacement, and under such circumstances the deformity is purely angular if present at all. Shortening of the arm is caused for the most part by the action of the biceps and triceps.

The humerus has a wider range of motion than any other bone in the body and the varieties of strain to which it may be subjected are great. Accordingly we may see any type of fracture common to long bones. The shaft of the humerus is composed of a heavy tube of compact tissue which grows larger in circumference and lighter in structure as the extremities are approached.

The musculo-spiral nerve supplying the extensors and supinators descends obliquely, from above, downward and outward, between the two humeral heads of the triceps. It lies in contact with the bone in the musculo-spiral groove and in this position is particularly exposed to injury in fractures of the humeral shaft. It may be injured by direct contusion and laceration at the time of the accident or it may be subsequently caught and compressed by the callus.

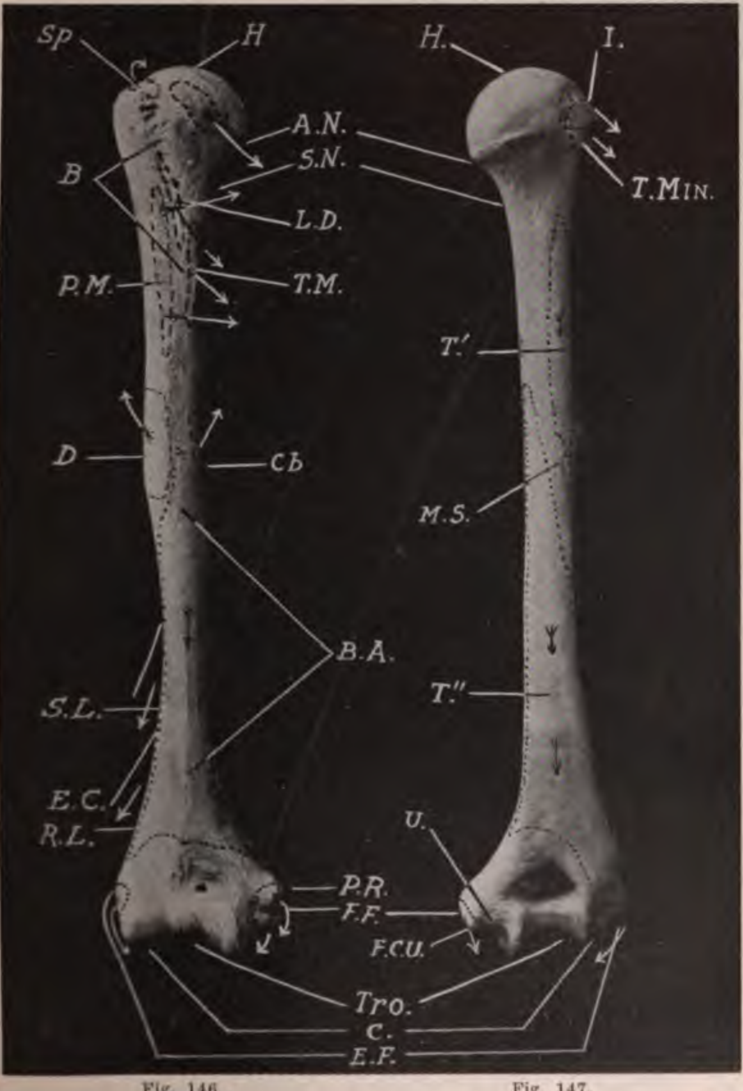

Fig. 146. Fig. 147.

Figs. 146 and 147.—Views of the anterior and posterior surfaces of the right humerus. The arrows indicate the pull of the attached muscles.

H., Head of the humerus; *A.N.*, Anatomical neck; *S.N.*, Surgical neck; *L.D.*, Attachment of the latissimus dorsi; *T.M.*, Attachment of the teres major; *Cb.*, Coracobrachialis; *T'*., Outer head of the triceps; *T''*., Inner head of the triceps; *M.S.*, Musculospiral groove; *B.*, Bicipital groove; *P.M.*, Insertion of the pectoralis major; *I.*, Infraspinatus; *T.Min.*, Teres minor; *D.*, Insertion of the deltoid; *S.L.*, Supinator longus; *E.C.R.L.*, Extensor carpi radialis longior; *U.*, Groove for ulnar nerve; *P.R.*, Pronator radii teres; *F.F.*, Flexors of the forearm; *F.C.U.*, Flexor carpi ulnaris; *Tro.*, Trochlear surface of humerus; *C.*, Capitellum; *E.F.*, Extensors of the forearm.

Inward displacement of one or both of the fragments may be the cause of laceration or compression of the brachial artery which lies to the inner side of the shaft.

Green-stick fractures are seldom seen and multiple breaks are uncommon. Direct violence is usually responsible for fractures of the transverse type; spiral and oblique fractures are the result of twisting strains. Muscular action is especially productive of fracture of the humeral shaft, and in some cases (particularly in elderly persons) the degree of causative trauma may be disproportionately small. Impaction of the fragments is almost never seen.

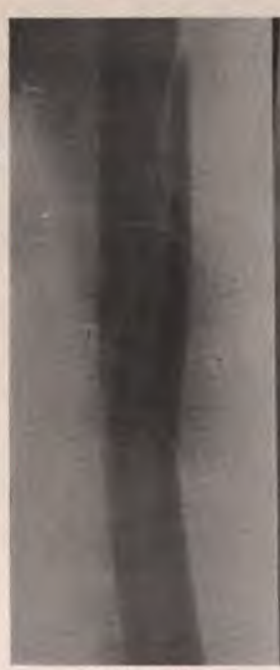

Fig. 148.

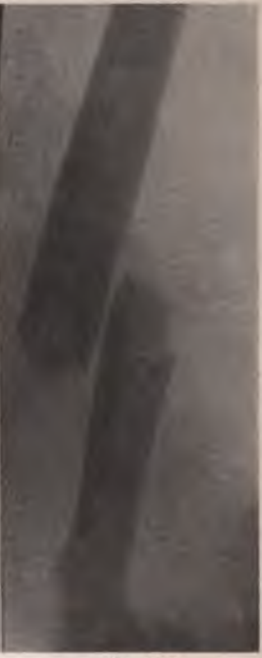

Fig. 149.

Fig. 148.—Spiral, comminuted fracture of humeral shaft.
Fig. 149.—Fracture of shaft with overriding and rotary deformity.

The most common seat of fracture is at or a little below the middle of the shaft.

Symptoms.—There is pain, loss of function, crepitus, abnormal mobility and varying deformity. Swelling usually develops rapidly and ecchymosis is seen within the first day. The relative position of the fragments varies with the level of the break and has been

explained under "Surgical Anatomy," page 108. The deformity is almost always sufficiently pronounced to be recognized by inspection alone.

The patient supports the injured member with the opposite hand in a manner which is characteristic. (See Diagnosis under "Dislocations of the Shoulder," page 65.)

The patient is able to move the hand and fingers, and the reflexes below the site of the fracture are intact unless some of the nerves have been injured.

Fig. 150.

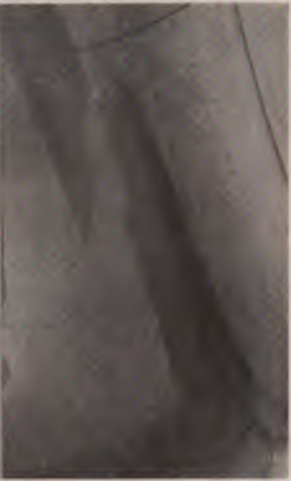

Fig. 151.

Fig. 150.—Multiple spiral fracture of humeral shaft with pronounced deformity.

Fig. 151.—Oblique fracture of humeral shaft with separation of fragments. (Taken through heavy fibre splint.)

A weakening or absence of the radial pulse indicates laceration or compression of the brachial artery.[1]

The development of a hematoma may sometimes be recognized in the arm following tearing of the artery.

Diagnosis.—Fractures of the humeral shaft are, as a rule, recognized without difficulty. The deformity is usually so pronounced that the diagnosis can be made by inspection alone. As soon as the arm is manipulated the point of abnormal mobility is apparent in almost all cases. Fracture of the shaft is a common fracture and is not infrequently associated with injuries to neighboring bones or joints. The surgeon should therefore be systematic in his examination and determine the conditions of the clavicle, scapula, elbow, ribs, etc., before the diagnosis can be considered complete. An X-ray plate should be made to afford further information concerning the nature of the fracture.

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[1] A thrombosis of the brachial artery may be slow in forming and when it is the alteration in the pulse will be delayed.

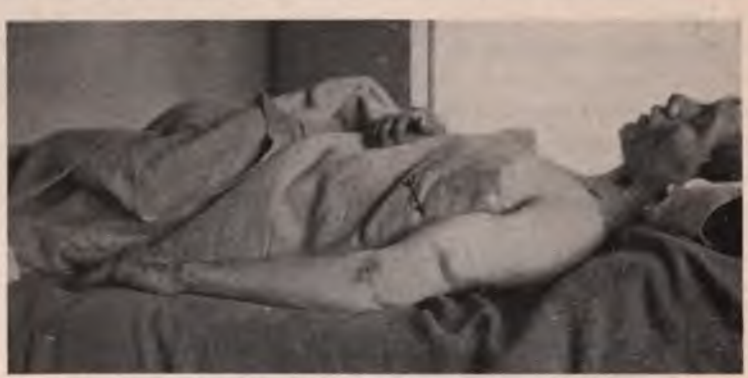


Fig. 152.—Oblique fracture of humerus a little below its middle with overriding and angular displacement of the fragments. Upper fragment anterior and external to lower fragment. Line of fracture passes below insertion of deltoid, hence the outward displacement of upper fragment, while the biceps and triceps cause the fragments to override. In this type of fracture complete reduction is often impossible without operative intervention. Photograph taken within an hour of the accident.

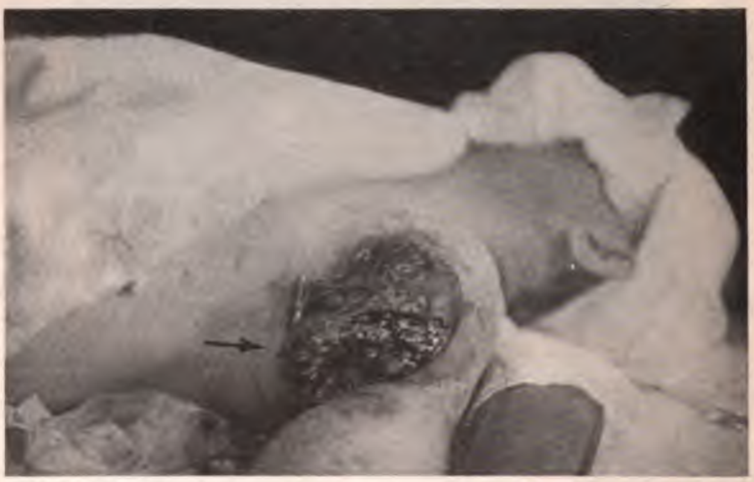


Fig. 153.—Crushing injury of arm. This case was struck by a falling wall, the humerus fractured and the upper portion of arm forced through rent in skin. Skin and fascia only tissues connecting upper and lower portions of arm. Arrow points to lower end of upper fragment directly above which may be seen tip of hemostat holding end of brachial artery. Amputation. Recovery. Photograph taken while patient is under anesthetic and just prior to operation.

Treatment.—The treatment will vary according to the location of the fracture and the direction and degree of displacement. It is best in most instances to reduce the deformity under anesthesia. Traction, counter-traction and manipulation will suffice in many cases to bring the fragments into proper apposition and alignment. In transverse fractures with overriding (especially when the ends are deeply serrated), reduction can best be effected by producing angular deformity and manipulating the fragments in this position until the serrated ends have been engaged. The bone is then straightened and appropriate dressings applied. In producing angular deformity for the purpose of engaging the ends, the arm should be bowed outward, to avoid stretching of the artery and nerves which lie on the inner side of the shaft. It is usually not difficult to effect reduction of a spiral or oblique fracture but it is frequently impossible to prevent recurrence of deformity in breaks of these types without resorting to internal fixation. Outward rotation of the upper fragment in a spiral or oblique fracture may act as a serious obstacle to reduction.

Fractures of the upper third of the shaft are to be treated with dressings such as already described in the Treatment of "Fractures of the Upper End of the Humerus" (page 101), namely axillary pad, plaster shoulder cap, cravat sling, body swathe, etc. There is this to be said, however, in regard to the shoulder cap; the lower the fracture the greater the need of extending this dressing downward to include the forearm. Coaptation splints are often used in fractures of the middle of the shaft though they may well be dispensed with, as a permanent dressing, in favor of a properly applied shoulder cap. It is a common practice to treat the condition during the onset and subsidence of swelling with the axillary pad, coaptation splints, body swathe and sling. Later on the coaptation splints are replaced by the plaster shoulder cap as a permanent dressing. In fractures of the lower third the elbow should be solidly immobilized. The axillary pad is not appropriate, and carrying the arm in a sling is entirely inadequate to secure fixation if the fracture is near the elbow. A most satisfactory method of fixation in this portion of the shaft is that shown in Fig. 215 and is described below.

The following may be considered a fair example of the treatment of a fracture of the shaft of the humerus shortly following the accident. The patient is placed in as comfortable a position as possible, preferably the recumbent, and an examination made of the parts, to determine as accurately as may be the exact nature and position of the fracture. The examination is more satisfactorily carried out under anesthesia. It should be remembered that the less the parts are manipulated the better it will be for the soft tissues surrounding the jagged ends of the fragments. After the fracture has been diagnosed the proper dressings should be prepared so that everything may be in readiness as soon as reduction has been effected.

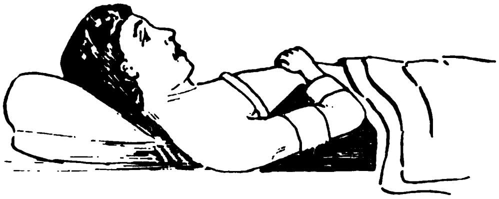


Fig. 154.—Stromeyer cushion.

It is needless to add that the surgeon should, at this time, satisfy himself as to which form of dressing will best meet the requirements of the case in hand. In instances in which the trauma has been great it is often best to leave the parts undisturbed and to treat the patient in the recumbent position for a week or ten days until the acute inflammatory reaction has subsided. During this time the arm may be supported on a pillow and the ice cap used to control the reaction. The Stromeyer cushion, or one of its modifications, may be used to advantage. If, on the other hand, it seems advisable to immobilize the arm at once the following details may be observed. The arm and side of the chest are sponged, dried and dusted with talcum powder, special attention being paid to the axilla. An axillary pad is then constructed as described on page

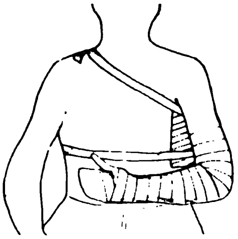


Fig. 155.

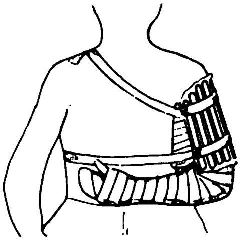


Fig. 156.

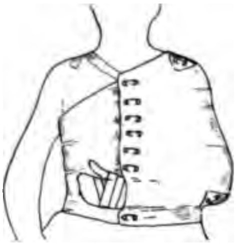


Fig. 157.

Fig. 155.—Arm bandaged and axillary pad in position.
Fig. 156.—Coaptation splints applied.
Fig. 157.—Swathe encircling body and acting as sling. (See Figs. 132 to 142 inclusive.)

100. Coaptation splints are next made by placing thin wood on adhesive plaster (cigar-box wood is excellent) and splitting the wood with a knife. The splint should include as much of the arm, from the shoulder to the elbow, as possible without pressing into the axillary fold above, or the top of the flexed forearm below. The portion of the coaptation splint on the outer side of the arm may be longer than that on the inner side. A body swathe is next prepared of two or three thicknesses of heavy muslin. It should be long enough to encircle the body and injured member and broad enough to extend from the top of the shoulder to a point below the elbow. A cravat sling is then prepared and the necessary materials are ready.

The axillary pad is placed in position and secured with adhesive plaster, after which the surgeon is ready to attempt reduction. The injured member is grasped above and below the seat of fracture, and the fragments gently but firmly manipulated until the senses of sight and touch pronounce the position satisfactory. The coaptation splint is then well padded, applied and secured in position with adhesive plaster. The arm is then firmly placed against the axillary pad and secured by the body swathe. The cravat sling completes the dressing, or in lieu of the sling the forearm may be included in the swathe, allowing the hand to emerge between the layers where they are pinned together. This form of dressing is least likely to strangulate the arm during the first week of treatment when the traumatic reaction and swelling are in progress.

A very satisfactory method of fixation in fractures below the middle of the shaft is one in which internal and external plaster splints are used, as shown in Fig. 215. These splints are made of plain gauze (from fifteen to twenty ply) and should be reinforced at the elbow by the insertion of additional layers of gauze between the layers of the splint. The external splint extends from a point well up on the shoulder, along the back of the arm and forearm to the wrist, while the internal splint extends from just below the axillary fold to the wrist on the anterior aspect of the upper extremity. They are applied to the injured member while wet and rapidly secured in position with a roller bandage. The surgeon holds the fragments in proper reduction until the plaster has set. Specific instructions should be given to the patient and his attendants not to allow the splints to be covered with clothing or bed covers for at least twenty-four hours so the plaster may become thoroughly dried out. One or two folded towels should be placed between the arm and the body, and a light swathe used encircling the chest and injured member. The following day the splints should be removed one at a time, lined with a layer of sheet cotton and replaced. The splints should then be secured in position by means of strips of adhesive plaster encircling the arm. The body swathe may be used in securing the arm by the side, or strips of adhesive may be used for this purpose. Sufficient padding should be placed in the external splint in the region of the olecranon to avoid chafing and discomfort. This dressing is quite secure but requires careful watching to avoid strangulation when swelling sets in. It is of particular advantage in compound fractures of the lower end of the humeral shaft since the arm may be permanently secured to one splint while the other is removed daily for inspection and dressing of the wound.

After the arm is immobilized (whatever the type of dressing may be) an X-ray should be taken, when possible, to verify the diagnosis and to determine the accuracy of reduction.

When overriding deformity cannot be corrected by solid engagement of the fractured ends weights may be attached to the elbow to control the action of the biceps and triceps. (Fig. 214.)

The use of extension may be indicated in some cases if employed in the recumbent position, but as an ambulatory method it is, in the author's opinion, entirely too haphazard and untrustworthy to be relied upon, notwithstanding statements to the contrary. It may be stated as a rule that fractures of the shaft requiring permanent extension to maintain reduction should be submitted to operation, and the fragments wired or plated in position. If ambulatory extension is employed, and fails, we have a condition of deformity which we know only too well might have been prevented by proper operative intervention.

Operative Treatment.—Fractures of the humeral shaft are frequently of the oblique or spiral type and accurate reduction is often impossible without open incision and internal fixation. The frequency with which one sees deformity following fractures of the humeral shaft treated by non-operative methods, indicates the value of open incision in the treatment of breaks in this region.

It is usually best to approach the bone through an external longitudinal incision of sufficient length to allow free access for manipulation and reduction. The greatest care should be used to avoid injury to the musculo-spiral nerve in making the incision and in accomplishing reduction and fixation. Destruction of the function of this nerve will be more disastrous to the patient than non-union of the fragments or union with deformity. It should be kept in mind therefore that it is possible for the surgeon to produce an injury which is far worse than the condition which he is operating to correct; accordingly the course of the musculo-spiral nerve should be thoroughly appreciated before operation in this region is attempted.

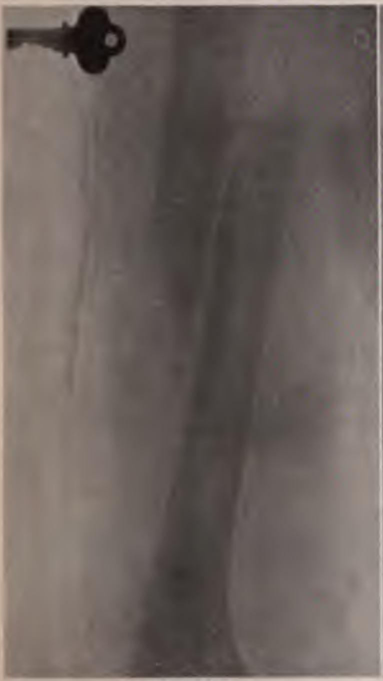


Fig. 158.

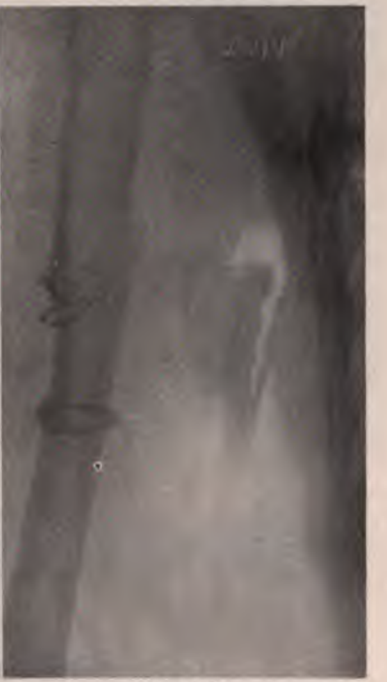


Fig. 159.

Fig. 158.—Röntgenogram of spiral fracture of humerus after two attempts at reduction. Rotary and lateral deformity present.

Fig. 159.—Same case after operation, showing fragments held in reduction by two wires. The lower wire encircles the bone while the other, at a higher level, penetrates the shaft and secures leverage for the lower wire.

After the fragments have been exposed the nature of the fracture is accurately ascertained, reduction accomplished and the best method of fixation determined. Each case must be considered by itself, and the nature of the deformity fully appreciated before

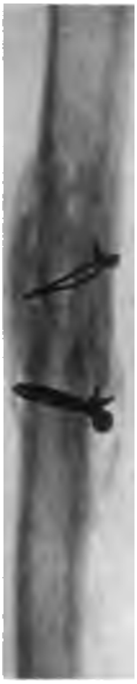


Fig. 160.

Fig. 160.—X-ray of same bone after it had been removed from soft tissues. Note the density and disposition of the callus nine months after operation and compare this plate with the photographs of the bone shown in Figs. 161, 162 and 163.

Figs. 161, 162 and 163.—Same case as shown in Figs. 158, 159 and 160. Patient had suffered from chronic chorea for past twenty-five years and sustained fracture as a result of the staggering gait which caused the fall. Fixation was particularly difficult on account of the nature of the fracture and the choreoid spasms and wiring was resorted to. Nine months later patient died in the terminal dementia following Huntingdon's chorea and humerus was obtained at autopsy. By comparing this specimen with Figs. 158, 159 and 160 the disposition of the callus covering the wire will be readily appreciated. The wire A encircling the shaft has been covered by callus where it crosses the line of fracture. The wire B was passed through a drill hole in both fragments and did not encircle the shaft; this wire also is covered [illegible] where it crosses the line of fracture. [illegible] of fracture was complete some months [illegible]. The dotted outline shows where the [illegible] nerve crosses the bone in the fresh specimen; wire A was originally passed between the [illegible] and the bone.

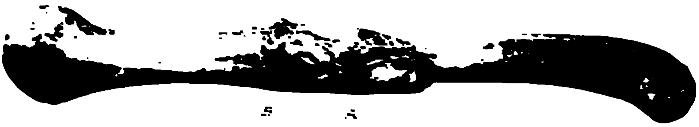


Fig. 161.

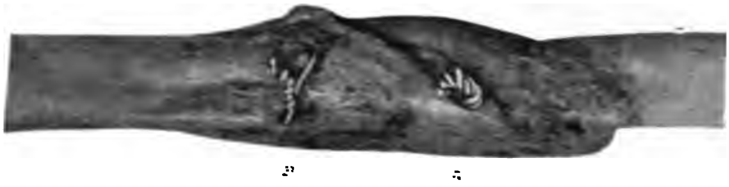


Fig. 162.

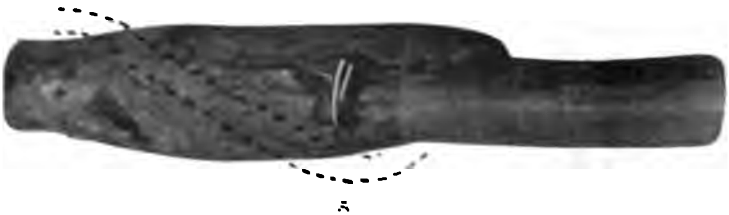


Fig. 163.

internal fixation is employed. Lateral displacement and overriding deformity in spiral fractures can usually be prevented by a wire encircling the shaft and including both fragments. (See Figs. 158 and 159.) A second wire is then placed a short distance from the first to secure the proper leverage in preventing angular deformity. In passing the circular wire about the shaft some form of hook (such as shown in Fig. 826) should be used to avoid including the musculo-spiral nerve. The Lane plate has been used in this region with most satisfying results and has much to commend it (see page 766).

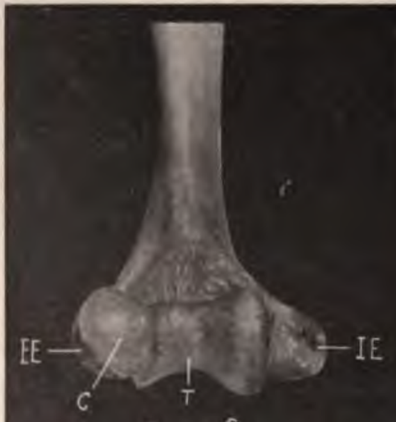
After-Treatment.—The after-care of fractures of the humeral shaft is as important as reduction. The bone is deeply seated and difficult to immobilize and the dressings require daily inspection and adjustment during the first ten days. Undue constriction of the parts must be avoided and still the dressings must be tight enough to properly support and immobilize the arm. In other words, the arm is changing in size because of the swelling, and the dressings must be made to vary accordingly, so they may fulfill their proper function. When fixation is satisfactory union should be present at the end of four weeks in children, and in from five to six weeks in adults. The older the patient the slower the bone will be in uniting. After the removal of splints the arm should be carried in a sling for another two or three weeks. Massage, early passive motion and hot applications will hasten the restoration of function. The arm should not be subjected to excessive strain for three to four months following the injury.

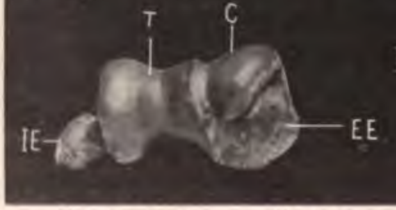
Prognosis.—In children and healthy young adults the restoration of function should be rapid and complete, if proper reduction and immobilization have been carried out, and union is usually firm at the end of four weeks. In adults five to six weeks is necessary. Non-union is more common here than in any other bone in the body, and is usually due to incomplete reduction or lack of proper immobilization. Laceration of the musculo-spiral nerve at the time of injury will be followed by paralysis and contractures, if not exposed and repaired. Even when the ends are united recovery is tedious and often incomplete. The development of paralysis of this nerve during the after-treatment may be due to compression by the callus and unless relieved by operation gives a bad prognosis.

CHAPTER IX.

FRACTURES OF THE LOWER END OF THE HUMERUS.

Surgical Anatomy.—The lower end of the humerus articulates with two bones; the types of these articulations are entirely different and the fractures occurring in this region are complex. The lower end of the bone curves forward and is flattened from before backward. The articular surfaces may be described roughly as a cylinder mounted on the lower end of the shaft, with the axis of the cylinder nearly transverse to the long axis of the shaft. The outer





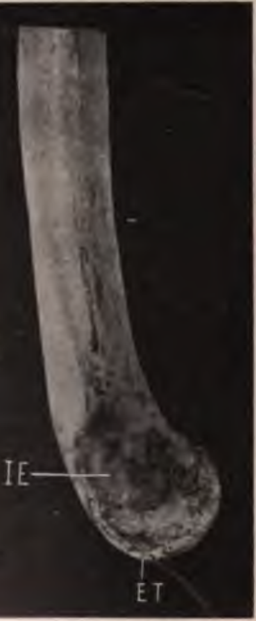


Fig. 164 (top). Fig. 165. Fig. 166.

Fig. 164.—Anterior surface of lower end of right humerus. *I.E.*, internal epicondyle; *C.*, capitellum; *T.*, trochlea.

Fig. 165.—Lower end of left humerus seen from below. *T.*, trochlea; *C.*, capitellum; *I.E.*, internal epicondyle; *E.E.*, external epicondyle.

Fig. 166.—Mesial aspect of lower end of left humerus. *I.E.*, internal epicondyle; *E.T.*, edge of trochlea.

end of the cylinder is at a slightly higher level than the inner end. When the elbow is fully extended the arm and forearm are not in the same straight line but form an angle of about 170 degrees. The difference between this angle and a straight line is 10 degrees, half of which is caused by the obliquity of the articular surfaces of the lower end of the humerus, while the other half is the result of the position of the bones of the forearm. In complete extension, therefore, we have the "carrying angle" while in complete flexion the forearm comes in contact with and folds directly upon the arm. When the fragments, in fractures of the lower end of the humerus, are allowed to unite in deformity there may be a disturbance in the carrying angle which is apparent when the arm is extended, and in addition there may also be a deformity in which the forearm does not fold directly against the arm in acute flexion. The carrying angle varies considerably in different individuals and the examination should therefore include comparison with the uninjured elbow.

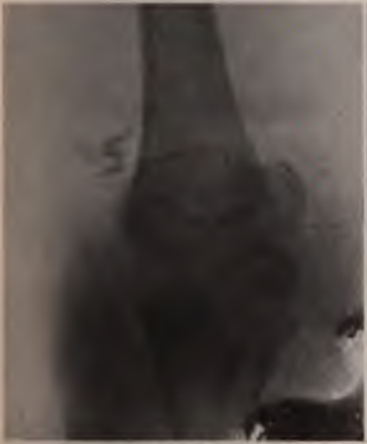


Fig. 167.

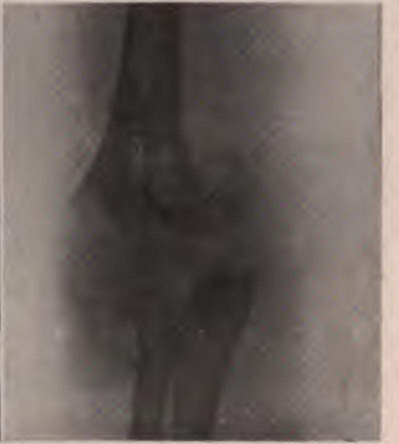


Fig. 168.

Fig. 167.—"Crescentic" fracture of lower end of humerus. Slight lateral displacement.

Fig. 168.—"Crescentic" fracture of lower end of humerus with more pronounced lateral displacement.

A certain amount of hyperextension is normal in the elbow, and by means of this position longitudinal stress may be borne by the upper extremity independently of the extensor muscles, the action resembling that seen in the knee when the joint is hyperextended.

The lower end of the humerus is deserving of detailed consideration so that the fractures occurring in this portion of the bone may be more thoroughly understood.

The external condyle (epicondyle) is a small, tubercular eminence situated just above and a little external to the capitellum. It affords attachment to the external lateral ligament and some of the extensor and supinator muscles of the forearm. It is rarely fractured without at least a portion of the capitellum being included with the fragment.

The capitellum is the rounded eminence occupying the outer part of the articular surface. It articulates with the head of the radius, and is rarely injured except when involved in some of the more common fractures of the external condyle. The radius articulates below with the carpus and above with the capitellum, and in falls on the hand violence is transmitted directly to the capitellum through the radius. This type of violence, however, is much more likely to produce Colle's fracture or a break in the shaft, neck or head of the radius. The obliquity of the fibres of the interosseous ligament enables the ulna to absorb a portion of the shock when violence is sustained in this way. The capitellum occupies only the front and lower part of the bone.

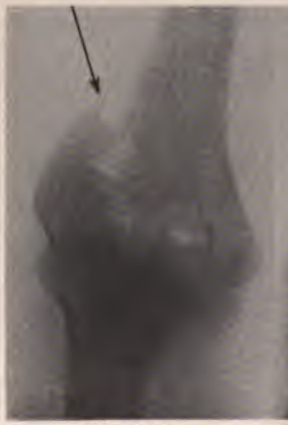


Fig. 169.

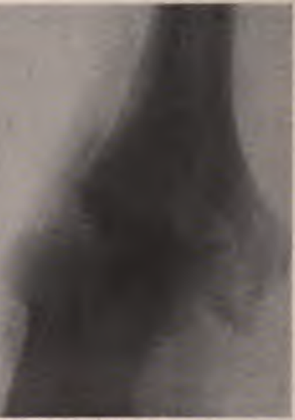


Fig. 170.

Fig. 169.—Vertical fracture of lower end of humerus separating external condyle from remainder of bone.

Fig. 170.—Fracture of the external condyle with lateral displacement of elbow. Fracture of the olecranon present but not discernible from this angle.

The inner portion of the articular surface is taken up by the

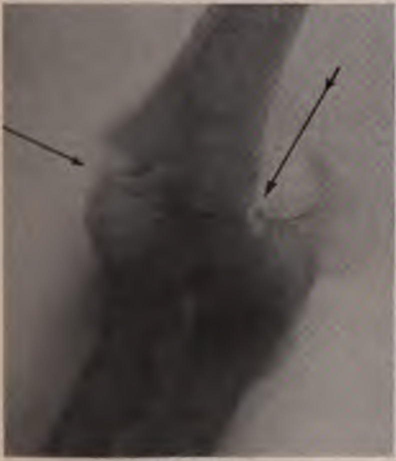


Fig. 171.

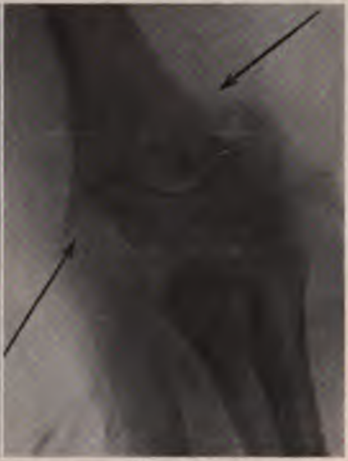


Fig. 172.

Fig. 171.—T-fracture of lower end of humerus. Pronounced inward and backward displacement of lower fragments.

Fig. 172.—''Crescentic'' fracture of lower end of humerus with lateral and backward displacement of lower fragment.

Fig. 173.

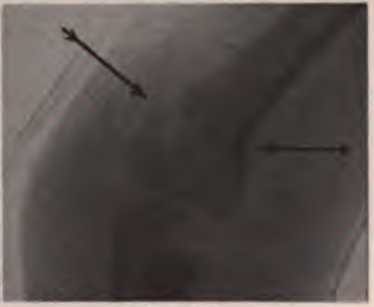


Fig. 174.

Fig. 173.—Supracondylar fracture with pronounced inward and backward displacement of lower fragment.

Fig. 174.—Same case after reduction.

trochlea which articulates with the greater sigmoid cavity of the ulna. It presents a pronounced groove running from before backward which is bounded on either side by prominent ridges, the inner being the most marked and extending to a lower level. The trochlea is slightly spiral so that the posterior end is a little external to the anterior extremity. Just above the anterior end of the trochlea is situated the coronoid fossa which, during flexion of the elbow, receives the process on the ulna of the same name. On the posterior aspect of the bone in the same corresponding position is found the olecranon fossa. These two fossæ are ordinarily separated by only a thin layer of bone and when the depressions are well marked the bone may be perforated, forming the supracondylar foramen. These two fossæ materially weaken the construction of the lower end of the humerus and are usually entered by transverse

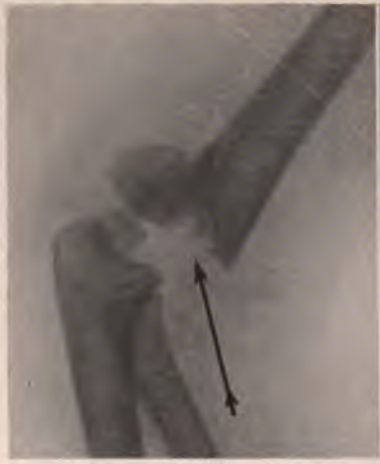


Fig. 175.

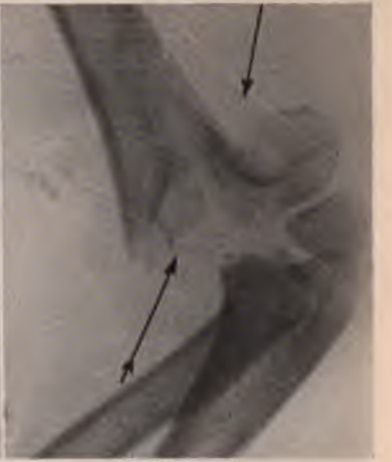


Fig. 176.

Fig. 175.—"Crescentic" fracture with backward and rotary displacement.

Fig. 176.—Fracture of lower end of humerus with backward and rotary displacement.

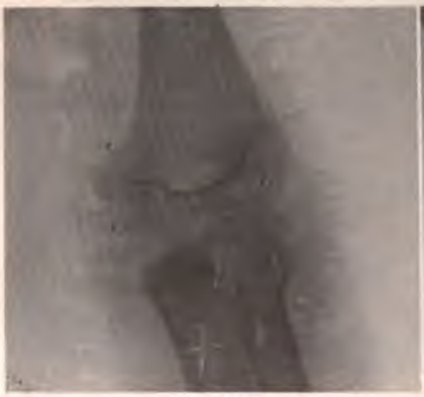


Fig. 177.

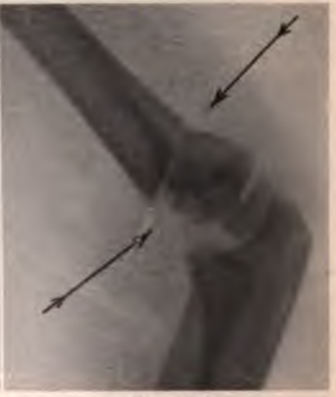


Fig. 178.

Fig. 177.—Fracture of lower end of humerus. Deformity not apparent in anteroposterior view.

Fig. 178.—Same case seen laterally. Slight backward displacement of lower fragment.

fractures in this region, and by vertical fractures involving the articular surfaces.

The internal condyle (epitrochlea) is much more prominent and larger than the external condyle, and affords attachment to the internal lateral ligament and some of the pronators and flexors of the forearm. It is more easily broken than the external condyle. Directly behind this process is a groove for the ulnar nerve which is not infrequently injured in fractures of the internal condyle.

The manner in which the lower epiphysis of the humerus is ossified is of importance in explaining epiphyseal separations in this region, though the resultant conditions are treated in a manner similar to fractures of the same parts. At birth the epiphysis is entirely cartilaginous and throws no shadow under the X-ray, while the lower end of the diaphysis is rounded. (See Fig. 251.)

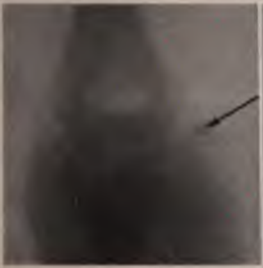


Fig. 179.

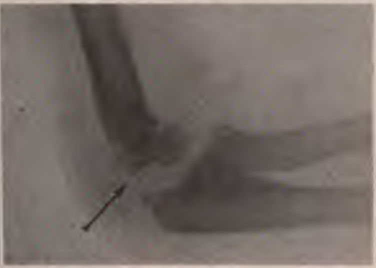


Fig. 180.

Fig. 179.—Epiphyseal separation of epitrochlea.
Fig. 180.—Lateral view of same case.

Before the end of the first year the center for the capitellum makes its appearance. At the sixth year the center for the internal condyle is seen; during the eleventh year the trochlea begins to ossify and the center for the external condyle is first seen during the twelfth year. The outer three centers usually fuse with each other and join the diaphysis during the fifteenth year, before the center for the epitrochlea becomes continuous with either epiphysis or diaphysis. The internal condyle joins the rest of the bone at about the eighteenth year. During the latter part of the development of the lower end of the humerus the diaphysis is seen to project progressively further into the epiphysis so that it comes nearly to the surface between the centers for the internal epicondyle and trochlea. The order in which these centers join the shaft and the thinning of the epiphysis between the trochlea and internal epicondyle account for the relative frequency of epiphyseal separations of the internal epicondyle.

The ligaments about the elbow play an important part in production of fractures. With the elbow partially flexed, abduction or adduction of the forearm produces rotation of the humerus. With the elbow fully extended, however, there is practically no rotary effect on the humerus but instead extreme tension is produced on one of the lateral ligaments. If the forearm is abducted the head of the radius is forced against the capitellum and the internal lateral ligament is placed under tension. If the violence is sufficient the capitellum is fractured, or the bone supporting it is broken off from the remainder of the lower end of the humerus. Instead of either of these lesions the internal lateral ligament may suffer rupture, or an equivalent fracture of the internal epicondyle or trochlea may take place. When the elbow is extended and the forearm forcibly adducted the reverse mechanism obtains.

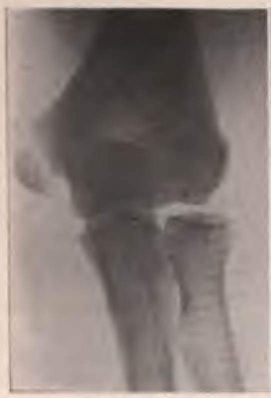


Fig. 181.

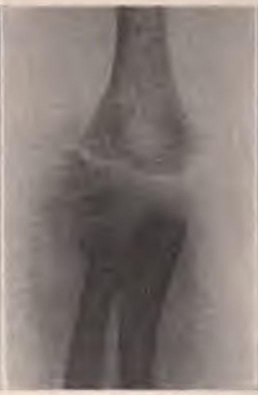


Fig. 182.

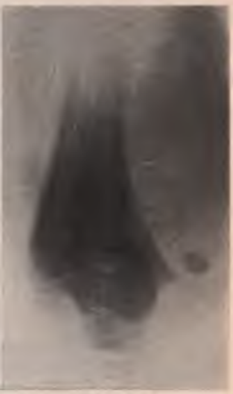


Fig. 183.

Fig. 181.—Fracture of internal epicondyle.
Fig. 182.—Separation of epiphysis of external condyle.
Fig. 183.—Separation of epiphysis of internal epicondyle.

If the forearm is forcibly extended beyond the normal limitations of motion the usual result is either rupture of the ligaments or fracture of the lower end of the humerus, with backward displacement of the fragment. A much more exceptional fracture is one produced by extreme flexion.

The types of fracture occurring in the lower end of the humerus are numerous, and have for the most part been named according internal fixation is employed. Lateral displacement and overriding deformity in spiral fractures can usually be prevented by a wire encircling the shaft and including both fragments. (See Figs. 158 and 159.) A second wire is then placed a short distance from the first to secure the proper leverage in preventing angular deformity. In passing the circular wire about the shaft some form of hook (such as shown in Fig. 826) should be used to avoid including the musculo-spiral nerve. The Lane plate has been used in this region with most satisfying results and has much to commend it (see page 766).

After-Treatment.—The after-care of fractures of the humeral shaft is as important as reduction. The bone is deeply seated and difficult to immobilize and the dressings require daily inspection and adjustment during the first ten days. Undue constriction of the parts must be avoided and still the dressings must be tight enough to properly support and immobilize the arm. In other words, the arm is changing in size because of the swelling, and the dressings must be made to vary accordingly, so they may fulfill their proper function. When fixation is satisfactory union should be present at the end of four weeks in children, and in from five to six weeks in adults. The older the patient the slower the bone will be in uniting. After the removal of splints the arm should be carried in a sling for another two or three weeks. Massage, early passive motion and hot applications will hasten the restoration of function. The arm should not be subjected to excessive strain for three to four months following the injury.

Prognosis.—In children and healthy young adults the restoration of function should be rapid and complete, if proper reduction and immobilization have been carried out, and union is usually firm at the end of four weeks. In adults five to six weeks is necessary. Non-union is more common here than in any other bone in the body, and is usually due to incomplete reduction or lack of proper immobilization. Laceration of the musculo-spiral nerve at the time of injury will be followed by paralysis and contractures, if not exposed and repaired. Even when the ends are united recovery is tedious and often incomplete. The development of paralysis of this nerve during the after-treatment may be due to compression by the callus and unless relieved by operation gives a bad prognosis.

CHAPTER IX.

FRACTURES OF THE LOWER END OF THE HUMERUS.

Surgical Anatomy.—The lower end of the humerus articulates with two bones; the types of these articulations are entirely different and the fractures occurring in this region are complex. The lower end of the bone curves forward and is flattened from before backward. The articular surfaces may be described roughly as a cylinder mounted on the lower end of the shaft, with the axis of the cylinder nearly transverse to the long axis of the shaft. The outer

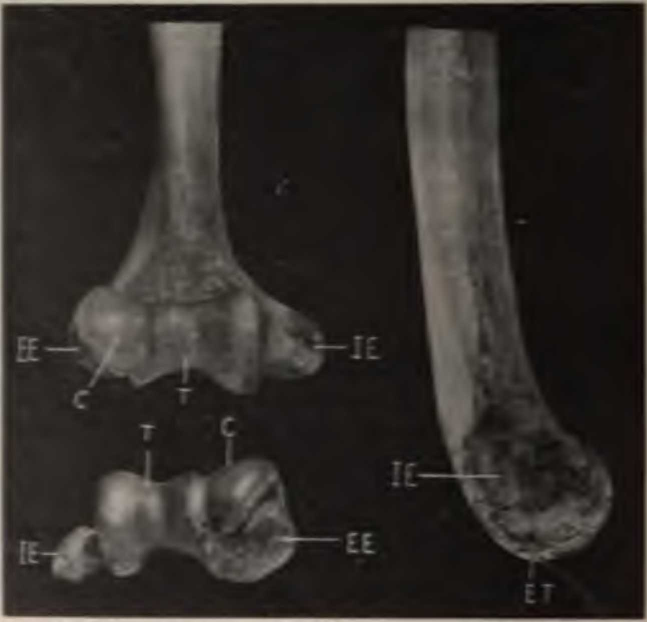


Fig. 164 (top). Fig. 165. Fig. 166.

Fig. 164.—Anterior surface of lower end of right humerus. *I.E.*, internal epicondyle; *C.*, capitellum; *T.*, trochlea.

Fig. 165.—Lower end of left humerus seen from below. *T.*, trochlea; *C.*, capitellum; *I.E.*, internal epicondyle; *E.E.*, external epicondyle.

Fig. 166.—Mesial aspect of lower end of left humerus. *I.E.*, internal epicondyle; *E.T.*, edge of trochlea.

reaction following fractures of the lower end of the humerus is usually pronounced, and a few days following the accident the region of the elbow may be covered with blebs containing blood or serum. Ecchymosis usually develops within twelve to twenty-four hours and may be extensive. The loss of function is usually complete following transverse fractures or those which involve the articular surfaces. In isolated fracture of either the epicondyle or epitrochlea the loss of function may be surprisingly slight. The patient will be able to use the elbow to some extent though of course the action of the part is somewhat limited by pain.

The symptoms peculiar to the different fractures in this region will be considered in detail.

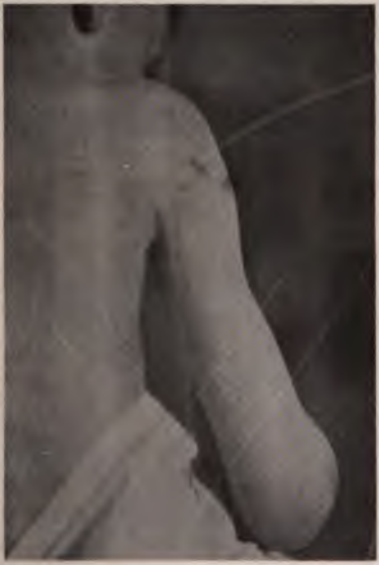


Fig. 184.—Fracture of external epicondyle with upward displacement of fragment. Prominence on external aspect of elbow suggestive; palpation reveals fragment. Joint is intact, there being no involvement of articular surface. Condition rare.

Fractures of the epicondyle (fractures in which the joint is not entered and the capitellum remains intact) are extremely rare and the symptoms are not pronounced. Moderate local swelling and tenderness in the region of the external condyle is present. The fragment may remain in position or may be displaced in any direction. When deformity exists the fragment is usually displaced downward. The detached particle of bone can, as a rule, be directly palpated and, if the fractured surfaces can be rubbed together, crepitus will be noted. Crepitus may be difficult to elicit if the fragment is not displaced and the swelling is pronounced. Detachment of the epicondyle will destroy, to a greater or less extent, the function of the external lateral ligament and accordingly the

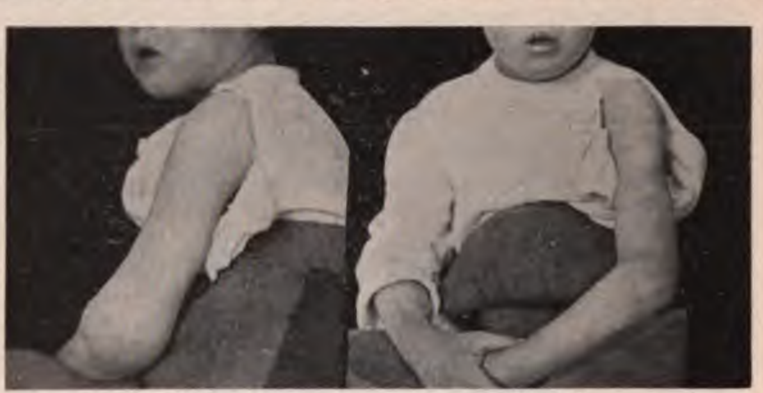


Fig. 185. Fig. 186.

Figs. 185 and 186.—Two views of a fracture of lower end of humerus without the characteristic backward displacement of lower fragment. Note prominence of external epicondyle which is detached. The joint remains intact and hence the absence of deformity such as seen in Figs. 188 and 189.

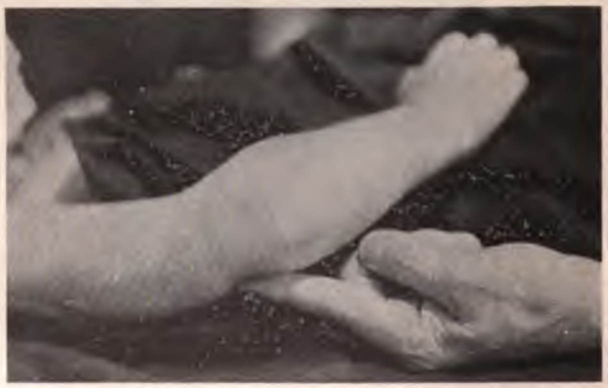


Fig. 187.—Splitting of lower end of humerus with separation of external condyle. Gun-stock deformity and abnormal lateral mobility. Picture taken a few hours following accident.

lateral stability of the elbow may be somewhat disturbed. A varying degree of abnormal adduction of the elbow is often possible.

Fractures of the external condyle (vertical fractures which enter the joint and include the capitellum in the detached fragment) are much more common than fractures of the epicondyle and the symptoms are decidedly more pronounced. Pain is severe, loss of function complete and swelling pronounced. The lateral stability of the elbow is usually completely lost and the joint is flail-like in a transverse direction. Crepitus is, as a rule, recognized as soon as the parts are manipulated. On palpating the condyles the epicondyle is found detached from the humerus, while the epitrochlea is continuous with the rest of the bone. The forearm is usually supported by the uninjured member and the patient is reluctant to release it for examination. When the arm hangs by the side the helplessness of the member is apparent and the usual "gunstock" deformity is recognized at a glance. The fragment is usually displaced downward and may be so rotated that the fractured surfaces are no longer parallel and facing each other (see Fig. 218).

Fractures of the internal condyle (vertical fractures entering the joint and separating all, or a portion, of the trochlea from the remainder of the bone). The symptoms are similar to those already described in the preceding type except that the inner side of the elbow is the most painful and tender, and the internal condyle is found to be the movable part. Loss of lateral stability is even more pronounced than in fracture of the external condyle.

Fracture of the epitrochlea (a vertical fracture separating the internal epicondyle from the remainder of the bone without entering the joint or involving the trochlea) is not an uncommon injury, and since neither the joint cavity nor the articular surfaces are involved the symptoms are usually slight. There is some local tenderness and pain on the inner side of the elbow, and ecchymosis is usually seen within the first day. Flexion and extension of the elbow are not painful except in as much as they disturb the detached fragment. Extreme extension or acute flexion may be attended by pain. Local swelling is usually present. The symptoms are often so slight that the condition is not infrequently mistaken for a sprain and treated as such.

Supracondylar and diacondylar fractures are similar conditions and the symptoms so resemble each other that they will be described together. Swelling, pain, tenderness, loss of function, crepitus, and mobility are present as in vertical fractures involving the articular surfaces. Loss of carrying angle and even gunstock deformity are usually prominent symptoms. The deformity is often characteristic, the bones of the forearm and humeral fragment being displaced backward in such a way as to produce a strong

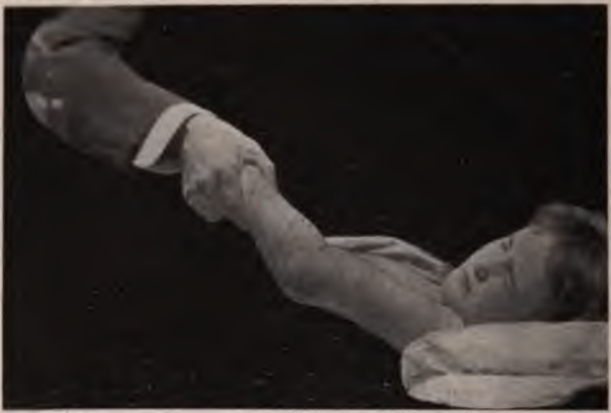


Fig. 188.—Transverse fracture of the lower end of the humerus. Note the backward displacement of the elbow. Palpation reveals the three bony prominences all displaced backward without disturbance in their relative positions. Sigmoid cavity of ulna not empty, as in Fig. 229. Picture taken about twenty-four hours following accident. Note swelling and slight ecchymosis.

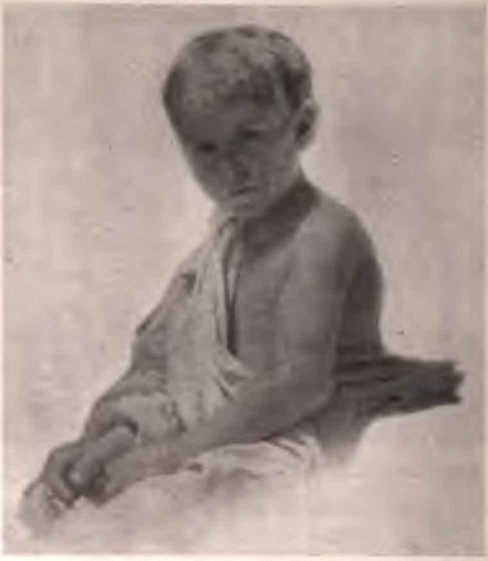


Fig. 189.—Same case in sitting position. Note that the deformity persists with change of position. The elbow is flail-like yet the action of the biceps and triceps produce and maintain the deformity.

trochlea which articulates with the greater sigmoid cavity of the ulna. It presents a pronounced groove running from before backward which is bounded on either side by prominent ridges, the inner being the most marked and extending to a lower level. The trochlea is slightly spiral so that the posterior end is a little external to the anterior extremity. Just above the anterior end of the trochlea is situated the coronoid fossa which, during flexion of the elbow, receives the process on the ulna of the same name. On the

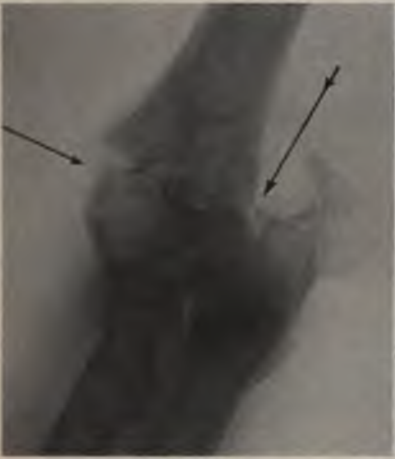


Fig. 171.

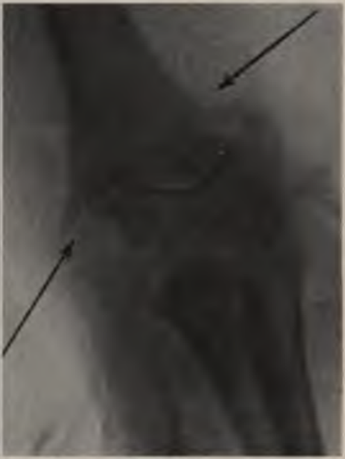


Fig. 172.

Fig. 171.—T-fracture of lower end of humerus. Pronounced inward and backward displacement of lower fragments.

Fig. 172.—"Crescentic" fracture of lower end of humerus with lateral and backward displacement of lower fragment.

Fig. 173.

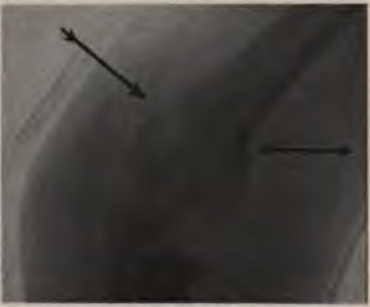


Fig. 174.

Fig. 173.—Supracondylar fracture with pronounced inward and backward displacement of lower fragment.

Fig. 174.—Same case after reduction.

posterior aspect of the bone in the same corresponding position is found the olecranon fossa. These two fossæ are ordinarily separated by only a thin layer of bone and when the depressions are

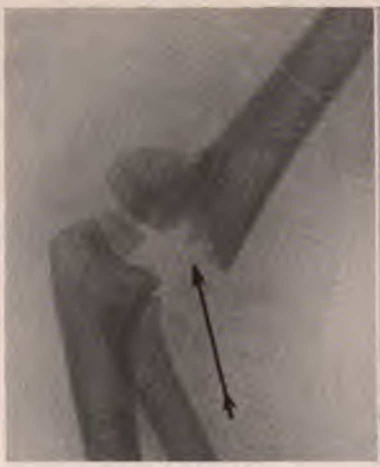


Fig. 175.

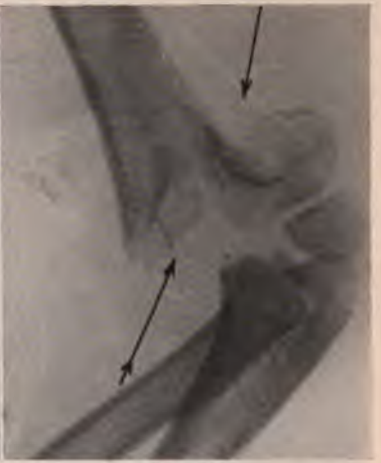


Fig. 176.

Fig. 175.—"Crescentic" fracture with backward and rotary displacement.

Fig. 176.—Fracture of lower end of humerus with backward and rotary displacement.

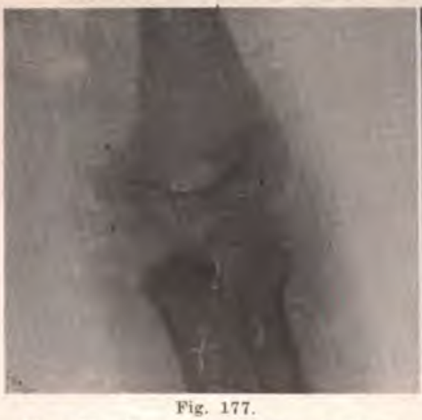


Fig. 177.

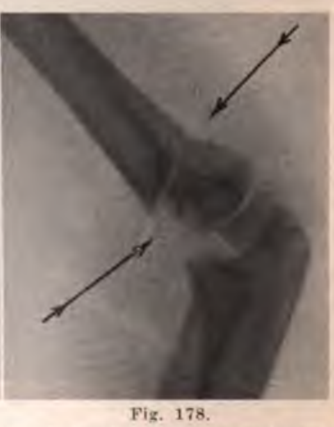


Fig. 178.

Fig. 177.—Fracture of lower end of humerus. Deformity not apparent in anteroposterior view.

Fig. 178.—Same case seen laterally. Slight backward displacement of lower fragment.

well marked the bone may be perforated, forming the supracondylar foramen. These two fossæ materially weaken the construction of the lower end of the humerus and are usually entered by transverse fractures in this region, and by vertical fractures involving the articular surfaces.

The internal condyle (epitrochlea) is much more prominent and larger than the external condyle, and affords attachment to the internal lateral ligament and some of the pronators and flexors of the forearm. It is more easily broken than the external condyle. Directly behind this process is a groove for the ulnar nerve which is not infrequently injured in fractures of the internal condyle.

The manner in which the lower epiphysis of the humerus is ossified is of importance in explaining epiphyseal separations in this region, though the resultant conditions are treated in a manner similar to fractures of the same parts. At birth the epiphysis is entirely cartilaginous and throws no shadow under the X-ray, while the lower end of the diaphysis is rounded. (See Fig. 251.)

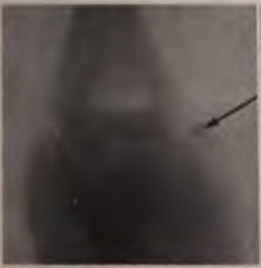


Fig. 179.

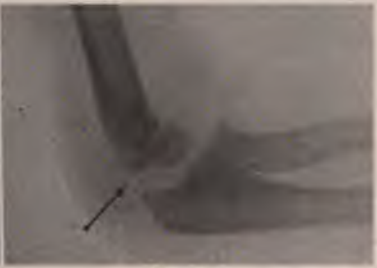


Fig. 180.

Fig. 179.—Epiphyseal separation of epitrochlea.
Fig. 180.—Lateral view of same case.

Before the end of the first year the center for the capitellum makes its appearance. At the sixth year the center for the internal condyle is seen; during the eleventh year the trochlea begins to ossify and the center for the external condyle is first seen during the twelfth year. The outer three centers usually fuse with each other and join the diaphysis during the fifteenth year, before the center for the epitrochlea becomes continuous with either epiphysis or diaphysis. The internal condyle joins the rest of the bone at about the eighteenth year. During the latter part of the development of the lower end of the humerus the diaphysis is seen to project progressively further into the epiphysis so that it comes nearly to the surface between the centers for the internal epicondyle and trochlea. The order in which these centers join the shaft and the thinning of the epiphysis between the trochlea and internal epicondyle account for the relative frequency of epiphyseal separations of the internal epicondyle.

The ligaments about the elbow play an important part in production of fractures. With the elbow partially flexed, abduction or adduction of the forearm produces rotation of the humerus. With the elbow fully extended, however, there is practically no rotary effect on the humerus but instead extreme tension is produced on one of the lateral ligaments. If the forearm is abducted the head of the radius is forced against the capitellum and the internal lateral ligament is placed under tension. If the violence is sufficient the capitellum is fractured, or the bone supporting it is broken off from the remainder of the lower end of the humerus. Instead of either of these lesions the internal lateral ligament may suffer rupture, or an equivalent fracture of the internal epicondyle or trochlea may take place. When the elbow is extended and the forearm forcibly adducted the reverse mechanism obtains.

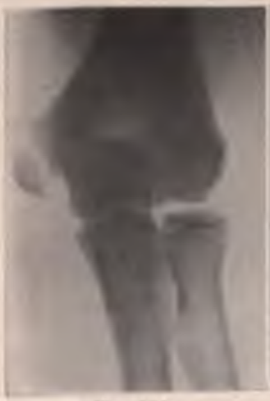


Fig. 181.

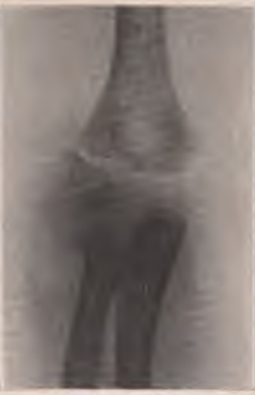


Fig. 182.

Fig. 183.

Fig. 181.—Fracture of internal epicondyle.
Fig. 182.—Separation of epiphysis of external condyle.
Fig. 183.—Separation of epiphysis of internal epicondyle.

If the forearm is forcibly extended beyond the normal limitations of motion the usual result is either rupture of the ligaments or fracture of the lower end of the humerus, with backward displacement of the fragment. A much more exceptional fracture is one produced by extreme flexion.

The types of fracture occurring in the lower end of the humerus are numerous, and have for the most part been named according to the portion of the bone involved. The terminology employed by different authors varies and the result has been rather confusing. The usual fractures occurring in this region are:

- Fracture of the epicondyle.
- Fracture of the external condyle including the capitellum.
- Fracture of the internal condyle including the trochlea.
- Fracture of the epitrochlea.
- Dia-condylar fracture, the break passing transversely through the condyles.
- Supra-condylar fracture, the break passing just above the condyles.
- T- or Y-fracture, in which a vertical break divides the lower fragment of a supra- or dia-condylar fracture.
- Comminuted fracture of the lower end of the humerus, in which the lower end of the bone is so broken up that it is difficult to recognize any particular type of fracture.
- Fracture limited to the capitellum as a result of violence transmitted through the radius in falls on the hand.
- Epiphyseal separations as described above.

It will be noted that all of the above fractures, except the last two named, may be described as either "transverse" or "vertical" or a combination of these two. The supra-condylar and dia-condylar fractures are essentially transverse, while the fractures involving the condyles and traversing the articular surfaces are vertical. The Y- or T-fracture shows both vertical and transverse elements. Nearly all transverse fractures pass through the olecranon fossa as do the vertical fractures involving the articular surfaces.

Transverse fractures are usually the result of forced hyperextension of the elbow, and the lower fragment is almost invariably displaced backward. In the typical transverse fracture the lower fragment is crescentic, the concavity looking upward. This type of fracture has frequently been mistaken for an epiphyseal separation in spite of the fact that there should be no difficulty in differentiating the two conditions when the X-ray is employed.

The upper end of vertical fractures may cross either the internal or external supracondylar ridge, but the lower end of the break is frequently placed so that the trochlea is separated from the capitellum. This separation of the two articular surfaces on the lower end of the humerus allows a flail-like lateral mobility at the elbow which is characteristic of the injury. A rare displacement, sometimes seen in transverse fractures, is one first described by Posadas, in which the lower fragment is displaced forward while the bones of the forearm are luxated backward.

When the condyles are separated from each other by a vertical fracture, one or both of the condyles may be displaced so that the relation of the three bony prominences is disturbed.

In the normal elbow the prominence of the olecranon and the two condyles should be about on the same straight line when the elbow is fully extended. The olecranon is a trifle nearer the inner condyle. When the elbow is in a position of acute flexion these three bony prominences should occupy the apices of an equilateral triangle. This anatomical relation is of great value both in diagnosis and treatment. The muscles attached to the condyles may exert a displacing action when either of these processes is detached. In vertical fractures the condyles are usually further apart than they should be, and the condyle on the detached fragment may be displaced forward, backward, upward or downward. In any fracture in which the lateral stability of the elbow is destroyed the carrying angle is lost as the arm hangs by the side, and if the condition is severe the forearm may diverge to the inner side, producing the familiar "gunstock deformity," or cubitus varus. This deformity may occur with any of the transverse fractures and with the vertical fractures involving the articular surfaces. Immediately following the accident this deformity is due to gravity and to the position occupied by the displaced fragment or fragments. If the fragments are not replaced and recurrence of displacement prevented the deformity will become permanent when union takes place.

In the rare T-fracture or in extensive comminution of the lower end of the humerus the lateral stability of the joint is most completely broken up since both condyles are separated from the shaft and from each other, and the line of fracture divides the articular surface. This type of fracture usually results from a fall directly on the flexed or semiflexed elbow.

Symptoms. The symptoms accompanying fractures of the lower end of the humerus vary considerably according to the position of the fracture and the severity of the lesion. Pain, swelling, local tenderness, loss of function and deformity are all present though they vary somewhat with the nature of the fracture. The traumatic reaction following fractures of the lower end of the humerus is usually pronounced, and a few days following the accident the region of the elbow may be covered with blebs containing blood or serum. Ecchymosis usually develops within twelve to twenty-four hours and may be extensive. The loss of function is usually complete following transverse fractures or those which involve the articular surfaces. In isolated fracture of either the epicondyle or epitrochlea the loss of function may be surprisingly slight. The patient will be able to use the elbow to some extent though of course the action of the part is somewhat limited by pain.

The symptoms peculiar to the different fractures in this region will be considered in detail.

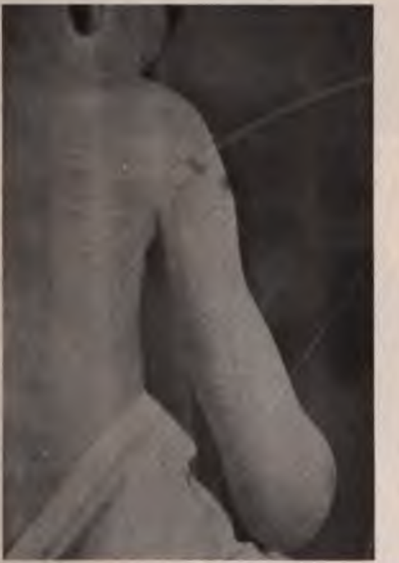


Fig. 184.—Fracture of external epicondyle with upward displacement of fragment. Prominence on external aspect of elbow suggestive; palpation reveals fragment. Joint is intact, there being no involvement of articular surface. Condition rare.

Fractures of the epicondyle (fractures in which the joint is not entered and the capitellum remains intact) are extremely rare and the symptoms are not pronounced. Moderate local swelling and tenderness in the region of the external condyle is present. The fragment may remain in position or may be displaced in any direction. When deformity exists the fragment is usually displaced downward. The detached particle of bone can, as a rule, be directly palpated and, if the fractured surfaces can be rubbed together, crepitus will be noted. Crepitus may be difficult to elicit if the fragment is not displaced and the swelling is pronounced. Detachment of the epicondyle will destroy, to a greater or less extent, the function of the external lateral ligament and accordingly the lateral stability of the elbow may be somewhat disturbed. A varying degree of abnormal adduction of the elbow is often possible.

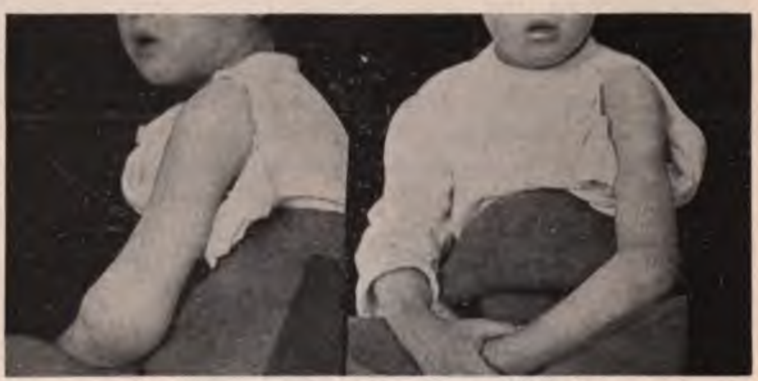


Fig. 185. Fig. 186.

Figs. 185 and 186.—Two views of a fracture of lower end of humerus without the characteristic backward displacement of lower fragment. Note prominence of external epicondyle which is detached. The joint remains intact and hence the absence of deformity such as seen in Figs. 188 and 189.

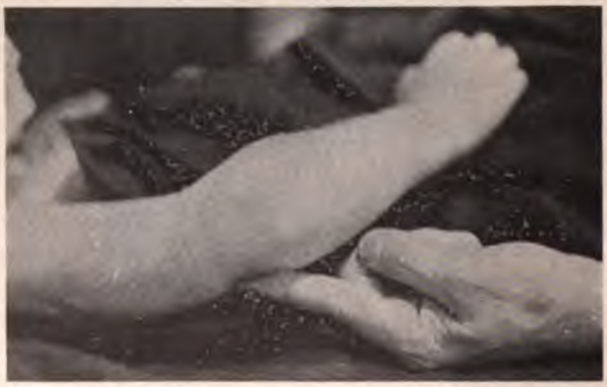


Fig. 187.—Splitting of lower end of humerus with separation of external condyle. Gun-stock deformity and abnormal lateral mobility. Picture taken a few hours following accident.

Fractures of the external condyle (vertical fractures which enter the joint and include the capitellum in the detached fragment) are much more common than fractures of the epicondyle and the symptoms are decidedly more pronounced. Pain is severe, loss of function complete and swelling pronounced. The lateral stability of the elbow is usually completely lost and the joint is flail-like in a transverse direction. Crepitus is, as a rule, recognized as soon as the parts are manipulated. On palpating the condyles the epicondyle is found detached from the humerus, while the epitrochlea is continuous with the rest of the bone. The forearm is usually supported by the uninjured member and the patient is reluctant to release it for examination. When the arm hangs by the side the helplessness of the member is apparent and the usual ''gunstock'' deformity is recognized at a glance. The fragment is usually displaced downward and may be so rotated that the fractured surfaces are no longer parallel and facing each other (see Fig. 218).

Fractures of the internal condyle (vertical fractures entering the joint and separating all, or a portion, of the trochlea from the remainder of the bone). The symptoms are similar to those already described in the preceding type except that the inner side of the elbow is the most painful and tender, and the internal condyle is found to be the movable part. Loss of lateral stability is even more pronounced than in fracture of the external condyle.

Fracture of the epitrochlea (a vertical fracture separating the internal epicondyle from the remainder of the bone without entering the joint or involving the trochlea) is not an uncommon injury, and since neither the joint cavity nor the articular surfaces are involved the symptoms are usually slight. There is some local tenderness and pain on the inner side of the elbow, and ecchymosis is usually seen within the first day. Flexion and extension of the elbow are not painful except in as much as they disturb the detached fragment. Extreme extension or acute flexion may be attended by pain. Local swelling is usually present. The symptoms are often so slight that the condition is not infrequently mistaken for a sprain and treated as such.

Supracondylar and diacondylar fractures are similar conditions and the symptoms so resemble each other that they will be described together. Swelling, pain, tenderness, loss of function, crepitus, and mobility are present as in vertical fractures involving the articular surfaces. Loss of carrying angle and even gunstock deformity are usually prominent symptoms. The deformity is often characteristic, the bones of the forearm and humeral fragment being displaced backward in such a way as to produce a strong

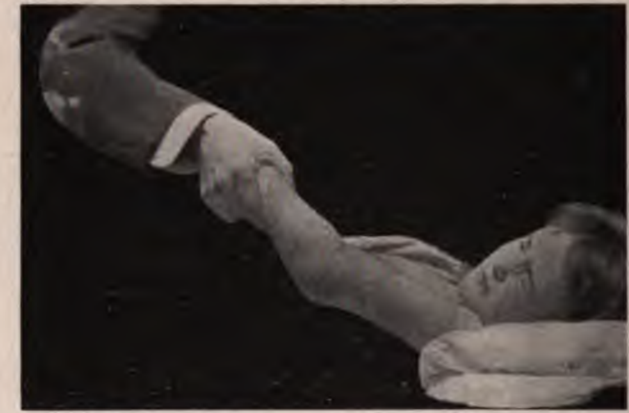


Fig. 188.—Transverse fracture of the lower end of the humerus. Note the backward displacement of the elbow. Palpation reveals the three bony prominences all displaced backward without disturbance in their relative positions. Sigmoid cavity of ulna not empty, as in Fig. 229. Picture taken about twenty-four hours following accident. Note swelling and slight ecchymosis.

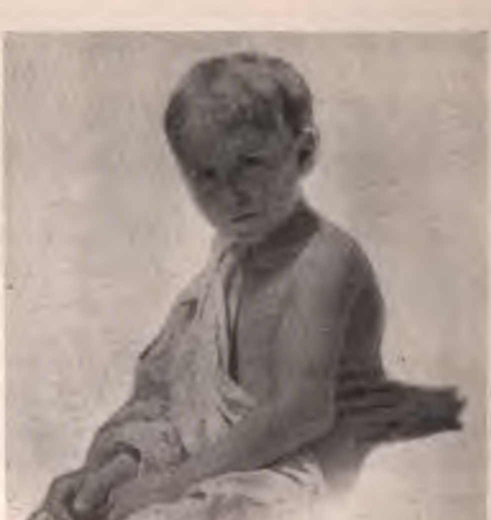


Fig. 189.—Same case in sitting position. Note that the deformity persists with change of position. The elbow is flail-like yet the action of the biceps and triceps produce and maintain the deformity.

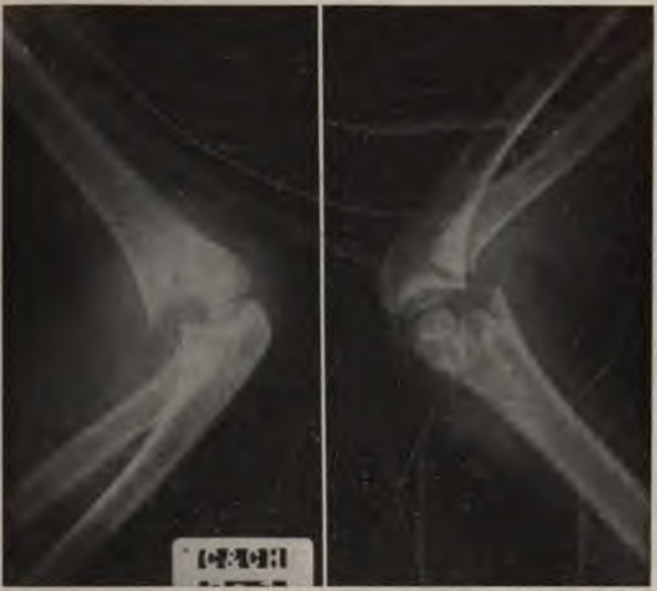


Fig. 190. Fig. 191.

Figs. 190 and 191.—X-ray plates of case shown in Figs. 188 and 189 after incomplete reduction.

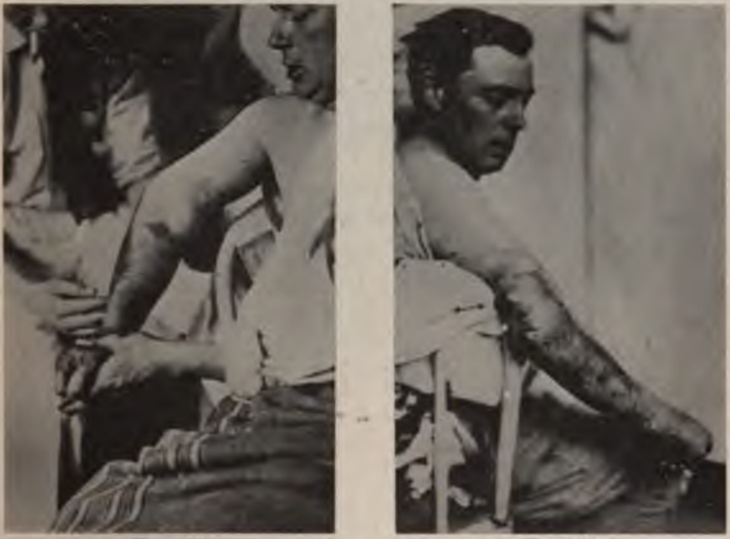


Fig. 192. Fig. 193.

Figs. 192 and 193.—Compound comminuted fracture of lower end of humerus. Note the backward and inward displacement which is characteristic. Forearm is covered with blood which accounts for its darkened condition in the photograph. Arrow points to the wound just above and behind the elbow. Picture taken about one hour after injury.

resemblance to backward dislocations of the elbow (see page 159). The character of the deformity is well shown in Figs. 188 and 189. On palpation the two condyles are found to be no longer continuous with the shaft of the humerus though they are continuous with each other and move together. If the upper end of the ulna is palpated the greater sigmoid cavity will be found occupied by the lower end of the humerus and not empty as in backward luxation. The lateral stability of the elbow is destroyed. The characteristic deformity of a supra- or dia-condylar fracture is first the backward displacement of the elbow and second the "gunstock" deformity. (See Figs. 192 and 193.)

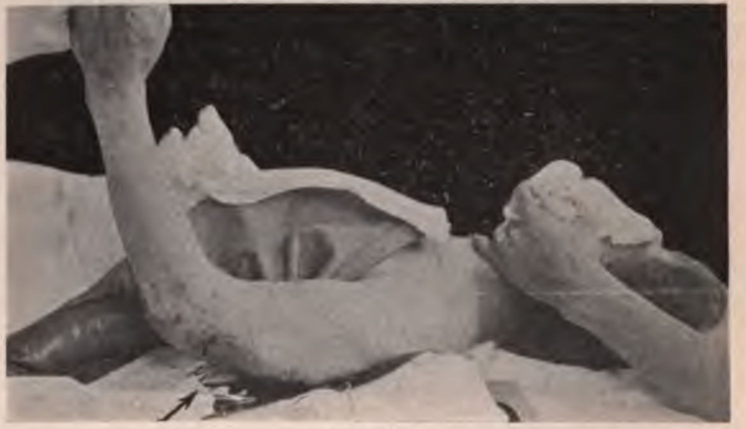


Fig. 194.

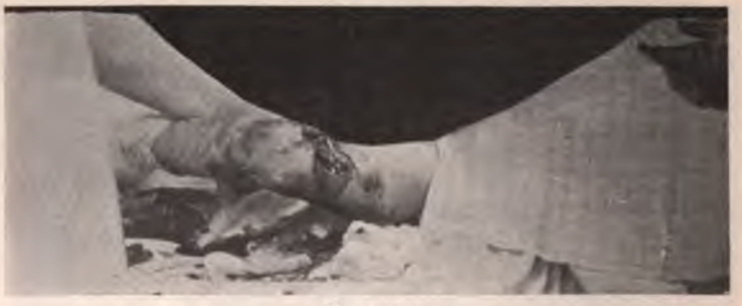


Fig. 195.

Figs. 194 and 195.—Compound comminuted fracture of the lower end of the humerus. Note the deformity and flail-like condition.

In the T- or Y-fracture of the lower end of the humerus or in *cases in which the lower end of the bone is extensively comminuted* practically all the symptoms of the above described transverse and vertical fractures are present in exaggerated form. The lateral

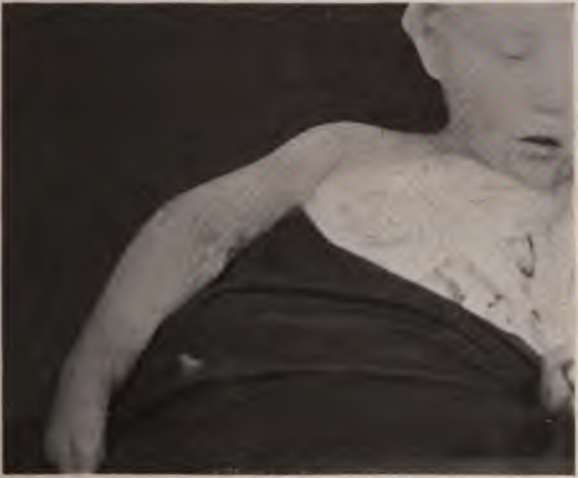


Fig. 196.

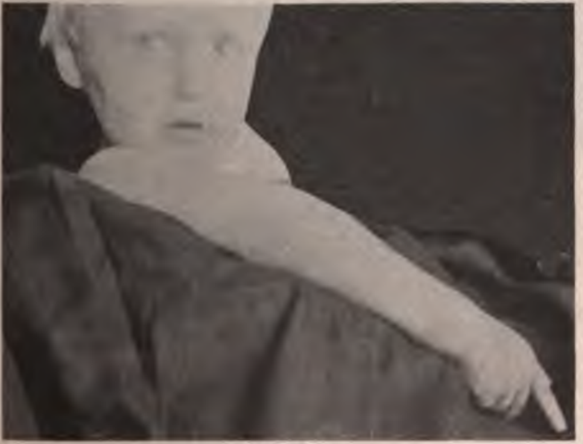


Fig. 197.

Figs. 196 and 197.—Old case of gunstock deformity and almost complete loss of function of elbow due to fractures above and below the joint. X-ray examination shows supracondylar fracture in lower end of humerus and fracture of ulna below coronoid process.

stability of the elbow is more completely destroyed in these types than in other forms of fracture in the lower end of the humerus. The traumatic reaction is usually severe and the fracture is not infrequently compound. On palpation crepitus is readily recognized, and when the comminution is extensive the region of the elbow may give one the sensation of a sack of marbles. When the condition is compound the wound is not infrequently located just above the olecranon on the posterior aspect of the arm.

Fracture limited to the capitellum is extremely rare and presents no characteristic symptoms. Local tenderness and pain with use of the elbow are present, but the condition is seldom recognized without the aid of the X-ray.

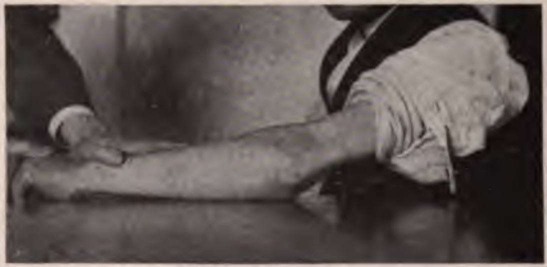


Fig. 198.

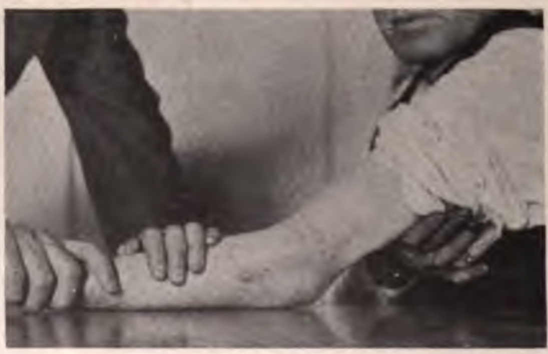


Fig. 199.

Figs. 198 and 199.—Old case of diacondylar fracture with the usual backward displacement of elbow. Deformity closely resembles backward luxation of the elbow. The characteristic depressions at the back of the elbow are absent and palpation of the sigmoid determines that it is not empty. (Compare with Figs. 225 to 230.)

Diagnosis.—The diagnosis of fractures of the lower end of the humerus is based on the symptoms just enumerated. Swelling about the elbow is usually rapid in onset and pronounced following fractures in this region, and the earlier the surgeon sees the case after the accident the less difficulty there will be in establishing a diagnosis. Firm, local, gentle and continued pressure in a given spot will in many cases so displace the fluids within the swollen tissues as to render recognition of the underlying bone possible.

If there is difficulty in determining the nature of the fracture the examination should be systematically conducted so that all the data possible may be gathered before the surgeon forms an opinion of the condition. If the traumatic reaction is pronounced it will usually be advisable to anesthetize the patient before examining the parts. The expense of repeated Röntgenographic examinations is frequently objected to by the patient, and under these circumstances it may be advisable to learn all that is possible from a physical examination under anesthesia, reduce the fracture and then have an X-ray plate taken to verify the diagnosis and the completeness of reduction at the same time. A careful inspection of the parts is of the greatest value and should be done before the arm is subjected to any manipulation whatever. The character of the deformity and the attitude of the patient will often be sufficient to indicate the nature of the injury so that the diagnosis is confirmed by the least possible manipulation and palpation. The less the parts are disturbed and the more gentle the manipulation the better. If inspection indicates the nature of the injury the surgeon should examine the part suspected first. Otherwise the lower end of the

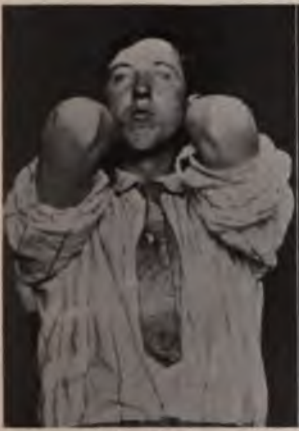


Fig. 200.

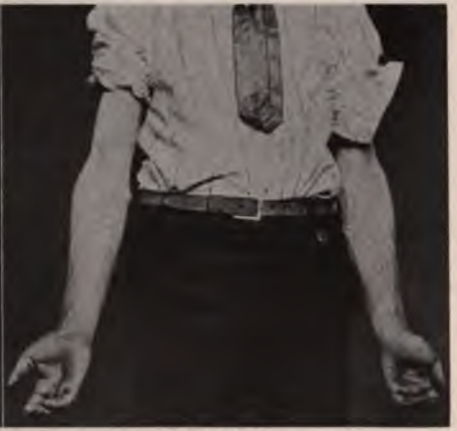


Fig. 201.

Fig. 200.—Examination of three bony prominences with elbows acutely flexed. Note the slight backward and upward displacement of the patient's right internal condyle.

Fig. 201.—With full extension it will be noted that there is a loss of carrying angle in the patient's right arm. The left arm is normal. Old fracture of lower end of right humerus.

bone should be covered systematically. The external condyle should be palpated and note made of whether or not the process is continuous with the shaft of the humerus and the opposite condyle. The same examination should then be made of the inner condyle. The lateral stability of the elbow should next be tested with the forearm fully extended. In determining this point the lower end of the arm is grasped above the elbow to steady the humerus while the opposite hand grasps the wrist and an attempt is made to adduct and then abduct the forearm. The wrist normally moves inward in passing from the position of supination to pronation, and the distance traversed is nearly equal to the breadth of the wrist. This motion, however, is accomplished entirely by the lower end of the radius encircling the head of the ulna and in

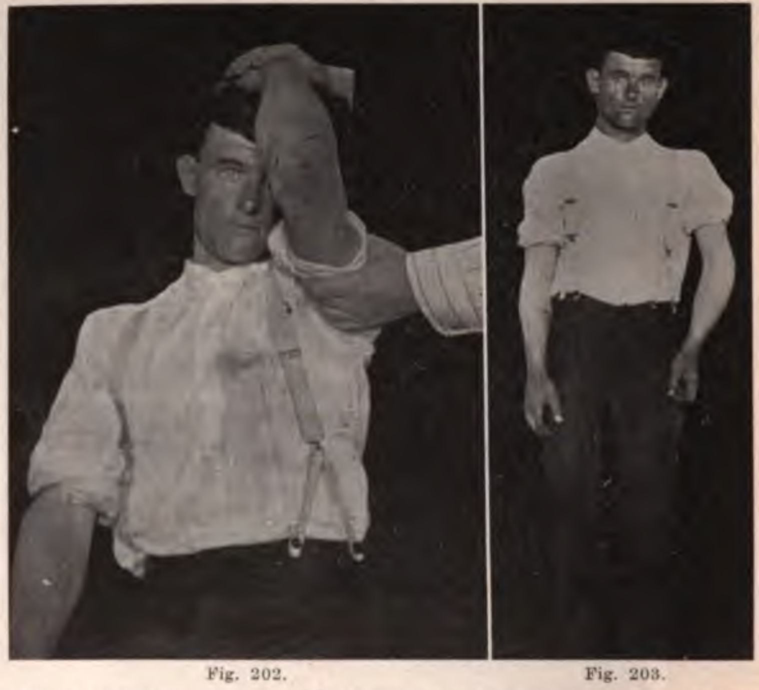


Fig. 202. Fig. 203.

Figs. 202 and 203.—Old fracture of lower end of humerus with union in deformity. Pronounced gun-stock deformity and shortening of arm. The positions of the three bony prominences have been marked and the displacement is apparent. A line drawn through the two condyles is not at right angles to the shaft of the humerus. By examining the elbow in this position one can tell the position which the forearm will occupy when extended. (See accompanying text.) Function good considering the deformity. Case first seen six years after the injury at which time these photographs were taken.

no wise means lateral motion at the elbow. Lateral motion does not exist in the normal elbow.

The relation of the three bony prominences of the elbow should be carefully noted, and if the normal relation is disturbed the surgeon should determine which of the prominences is displaced. The olecranon should be carefully palpated and its continuity with the ulnar shaft determined. The head of the radius should be palpated and note made of whether or not the head rotates with the radial shaft during pronation and supination of the forearm. The forearm should be carried through its normal range of motion and any restriction of action or pain should be noted.

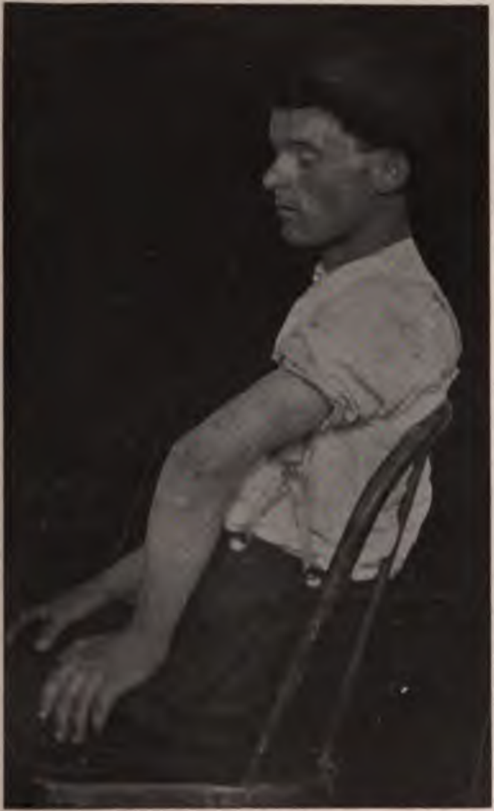


Fig. 204.—Another view of case shown in Figs. 202 and 203, showing the striking deformity.

The backward displacement accompanying transverse fractures of the lower end of the humerus closely resembles the deformity seen in backward luxations of the elbow. In luxations, however, the deformity is usually more pronounced and the sigmoid cavity is found empty on palpation (compare the appearances of the cases shown in Figs. 199 and 229). In fractures mobility is increased, while in luxations it is usually restricted.

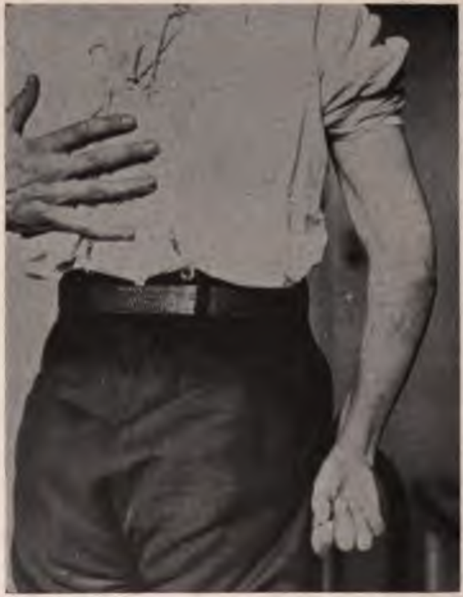


Fig. 205.—Fracture about two inches above the condyles three years after the accident. Note the inward angular displacement of the lower fragment and resultant gun-stock deformity. Paralysis result of injury to musculo-spiral nerve at the level of the fracture. Nerve injury not recognized at the time of the injury and nothing done subsequently to repair the damage. Patient has practically no use of the member. Case first seen by author at time of taking this photograph.

Fractures of the lower end of the humerus must be differentiated from

Dislocations of the elbow,
Dislocations of the ulna alone,
Dislocations of the radial head,
Fractures of the olecranon,
Fractures of the coronoid and ulna below the elbow,
Fractures of the radial head, neck, or shaft,
Simple sprain of the elbow.

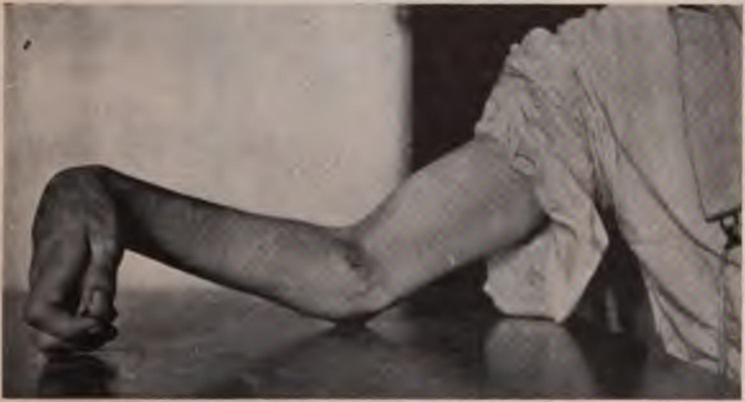


Fig. 206.—Another view of case shown in Fig. 205. Patient cannot extend arm beyond position shown here. Note waist-drop, contracture and atrophy.

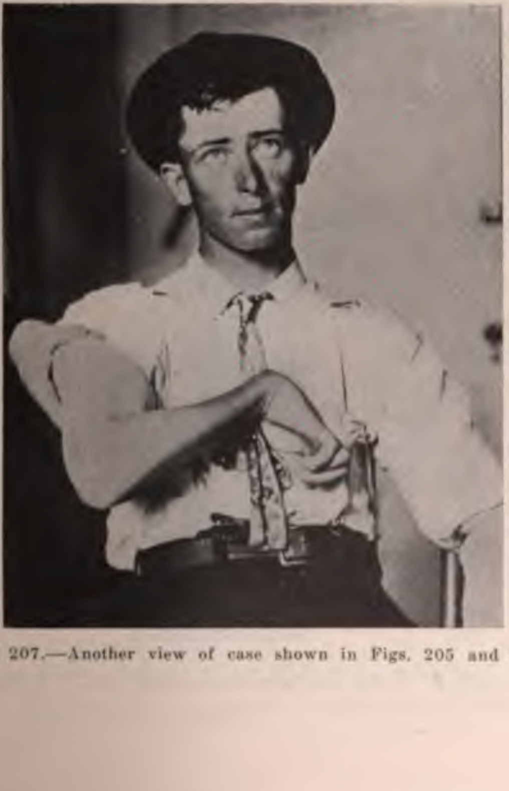


Fig. 207.—Another view of case shown in Figs. 205 and 206.

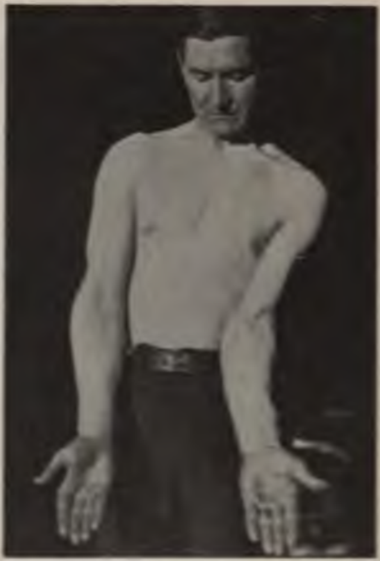


Fig. 208.—A rare case which demonstrates two deformities in the same patient. Both arms were broken some years ago just above the elbow and both elbow joints were involved. After union had taken place the deformities were recognized. Valgus in one elbow and varus in the opposite. The left arm shows exaggerated carrying angle while the right arm shows "gun-stock" deformity. Case first seen by author at the time this picture was taken. Function in both arms fair considering the deformities.

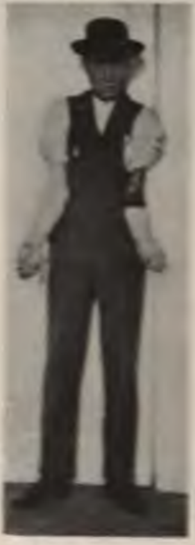


Fig. 209.—Picture taken to show how pronounced the normal carrying angle may be and the necessity of always examining the opposite elbow. (Left elbow has been painted with iodine following sprain.)

The reflexes and condition of the circulation below the level of the fracture should be tested both before and after reduction. The ulnar nerve is the structure most commonly injured, especially in fractures of the internal condyle, and its function should be most carefully tested.

The value of the X-ray cannot be overestimated in the diagnosis of fractures of the lower end of the humerus and should be made use of whenever possible. The plates taken should be at right angles to each other or else made stereoscopically.

Treatment.—An accurate appreciation of the nature of the fracture is essential to the intelligent treatment of fractures of the lower end of the humerus. As a rule anesthesia should be employed in reducing the displacement and in fixing the arm. Reduction is easily accomplished in many cases, yet it is not uncommon to encounter a condition in which reduction and fixation can be had only with open treatment. Transverse fractures can usually be reduced by grasping the lower end of the arm above the elbow to steady the humerus, and then making traction in the axis of the semiflexed forearm. This pulls the bones of the forearm forward and with them the lower fragment seated in the sigmoid cavity of the ulna. When the fragment has been brought back into position the elbow is flexed and immobilized in this position. Treatment of these fractures in acute flexion will give the best results in the greatest number of cases, yet the value of this position should not be overestimated nor should it be employed blindly. The best position in which to treat fractures of this region is the position which will most accurately and securely maintain reduction, and just which position this is must be determined in each and every case to the satisfaction of the surgeon. Much has been said and written of the value of the three bony prominences in the diagnosis of fractures about the elbow, yet their chief value lies in the treatment of these conditions and seems to have been overlooked. A careful consideration of these three points with the elbow flexed will enable the surgeon to determine the position the forearm will occupy when extended. This determination is made in much the same manner as one would foretell the position a door would occupy when open, by a study of the position of the hinges when closed. This point is well illustrated in Figs. 202 and 203. In reducing a fracture in this region the surgeon should have the two condyles directly under his touch, so that he may follow the effect on the fragments as the forearm is slowly carried through flexion and extension. The degree of flexion in which the fragments seem to occupy a position nearest to normal should be maintained, and dressings then applied which will immobilize the elbow. The two condyles should be in a line at right angles to the axis of the shaft of the humerus, and neither should occupy a position anterior to the other (taking the posterior surface of the humerus as a base). The tip of the olecranon should be at about the same level as the condyles if extension is complete, at the apex of an equilateral triangle in acute flexion and proportionately situated between these two points in the various degrees of flexion. It will usually be found that posterior displacement of the lower fragment is corrected, more or less completely, by acute flexion, and we therefore seldom find the extended position available in the treatment of these cases. An arm may appear well reduced in the flexed position, and the surgeon may be pleased with the outlook of the case, and yet after union has taken place, the splints removed and the arm extended, a condition such as shown in Fig. 203 may become evident, to the chagrin of the surgeon and the dissatisfaction of the patient. Such results might be avoided by a careful examination of the three bony prominences following reduction as described above.

In the treatment of vertical fractures involving the articular surfaces similar principles are to be followed out. Acute flexion, however, is not nearly as efficient in preventing recurrence of deformity in these vertical fractures as it is when the break is transverse. During reduction lateral pressure should be made on the fragments in order that they may be forced closer together. Measurements of the distance between the two condyles should be made following reduction and compared with the opposite elbow. In some instances a detached condyle may follow the movements of the forearm during flexion and extension, and when this occurs the elbow should be fixed in the degree of flexion in which the fragment occupies a position nearest to normal. If the fragment is rotated it may be necessary to operate to effect reduction. It should be remembered that the displacing action of the muscles of the forearm attached to the condyles varies with the degree of flexion of the elbow. In acute flexion the pull is upward and forward, in semiflexion it is forward, while in complete extension it is downward.

The principles involved in the treatment of epiphyseal separations are the same as those given in the treatment of fractures of the corresponding parts.

Special padding of the splint may be of aid in retaining the fragments though it is not so satisfactory a method as might be desired. Displacement depends somewhat on the extent to which the intermuscular septa and fasciæ have been torn, and accordingly we experience less difficulty in those cases in which the damage sustained by these tissues has been slight.

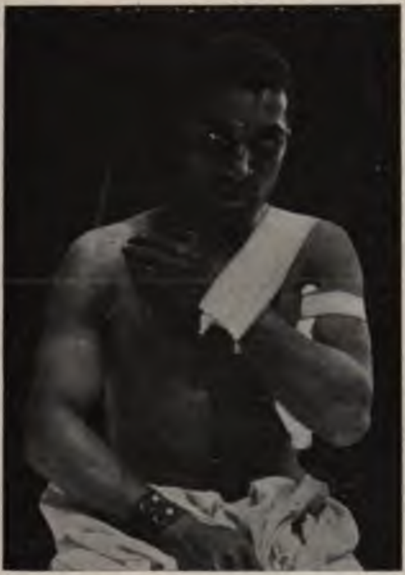


Fig. 210.—Method of fixing the arm in a position short of acute flexion for the treatment of certain fractures at the elbow. This method is far better than passing adhesive about the wrist and upper part of the arm as is commonly done.

Fractures entering the articular surfaces demand the most accurate reduction. Perfect apposition means a small callus and is essential to restoration of joint function.

The dressings employed to fix the part vary with the degree of flexion in which the elbow is immobilized. In cases in which the traumatic reaction is pronounced it is advisable to delay the application of dressings until it has subsided. During this time the patient should be in bed, the injured arm supported on a pillow and the ice cap applied at intervals.

If the position of acute flexion is to be employed layers of gauze should be placed in the bend of the elbow, and in the axilla, to absorb the secretions and prevent chafing of the skin. The inner surface of the arm and forearm should be prevented from coming in contact with the chest for the same reasons. This is accomplished by layers of gauze appropriately placed. The usual method of maintaining acute flexion by means of a strip of adhesive binding the wrist to the upper part of the arm, is mechanically cumber-

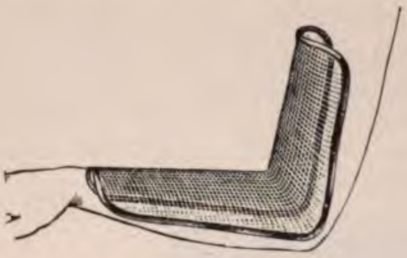


Fig. 211.

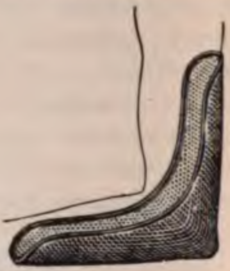


Fig. 212.

Fig. 211.—Internal right angle Dupuy splint.
Fig. 212.—External right angle Dupuy splint.

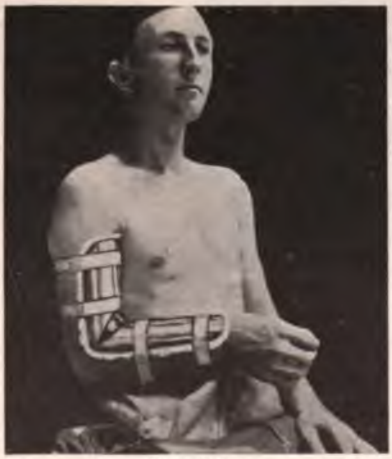


Fig. 213.

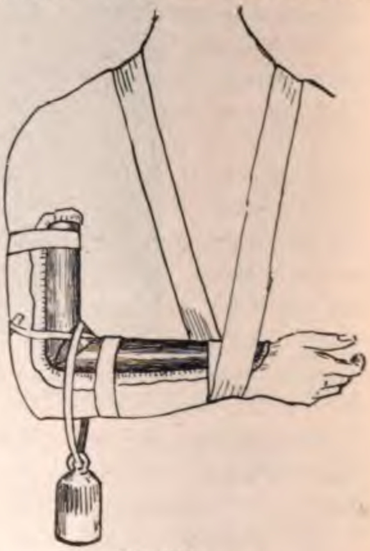


Fig. 214.

Fig. 213.—Internal, right-angle splint padded and secured in position with four strips of adhesive plaster.

Fig. 214.—Method of securing traction with right-angle splint and weight. Seldom advisable. (See text.)

some and productive of discomfort. The most satisfactory method of securing the upper extremity in this position is shown in Fig. 210. A strip of adhesive encircles the wrist and passes over the shoulder of the same side. In this way any position from semiflexion to the most acute flexion may be had, and the amount of flexion may be increased from time to time during the subsidence of the swelling with the least possible disturbance of the elbow. If additional security is desired the axillary pad may be employed as described in the "Treatment of Fractures of the Upper End of the Humerus" on page 99. A body swathe may be used to secure the arm to the side.

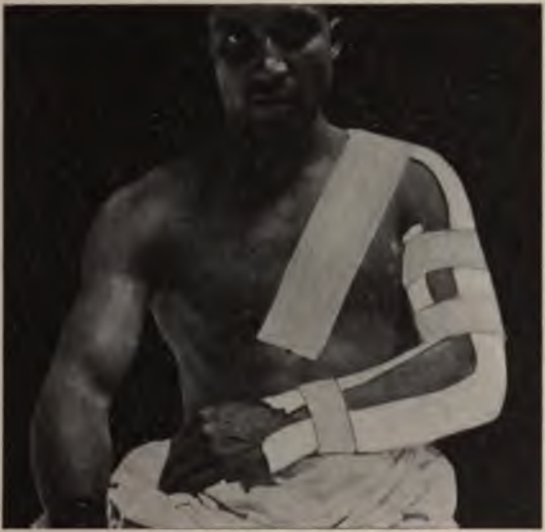


Fig. 215.—Plaster splints applied to upper extremity and held in position by straps of adhesive plaster.

If a position of semiflexion is chosen in which to immobilize the elbow the ordinary right angle splint may be employed. Either an internal or an external right angle splint will accomplish the purpose, though the former is usually preferable. This splint should be secured to the arm first by strips of adhesive, and then fastened to the forearm while traction is being made on the wrist to draw the fragment forward.

When it is necessary to immobilize the forearm in positions between complete extension and semiflexion, plaster splints will usually be found most satisfactory (see Fig. 215).

Any form of splint applied to the upper extremity should be well padded with sheet cotton, and the encircling bandages or strips of adhesive used to secure it in position should not be so tightly applied as to cause constriction of the member. This precaution is of the greatest importance during the onset of swelling and if not observed may result in great damage. A dressing may fit properly at the time of application and yet a few hours later may be causing serious constriction. After the height of the traumatic reaction has passed and the size of the arm and forearm is diminishing, snug bandaging will often accomplish much in reducing the swelling.

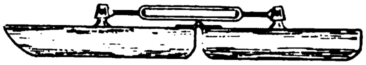


Fig. 216.

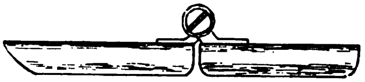


Fig. 217.

Figs. 216 and 217.—Two types of adjustable splints for use in fractures about the elbow.

Operative Treatment.—The open method is productive of the best results in many cases and we should not hesitate to resort to it when the proper surgical facilities are available and the ordinary methods are not efficient. No surgeon should operate on the lower end of the humerus without having well in mind the details of the anatomy of the region. The bone is peculiarly shaped, and without an accurate knowledge of its formation and the structures surrounding it, the surgeon may do more harm than good. There is considerable compact tissue in the region of the condyles and above them in the shaft, but the bony structure supporting the articular surfaces is altogether cancellous. In order to acquire a good appreciation of the internal structure of the bone it will more than repay the student to open a humerus in coronal and sagittal section, using an ordinary hack-saw for the purpose, after which he may study the nature of the bone structure with which he has to work. In placing wire or nails we should rely as much as possible on the compact tissue; a knowledge of its disposition and density will be of the greatest value.

It is better to approach the fragments through an internal longitudinal incision or an external longitudinal incision or both, and to avoid, as much as possible, injury to the soft tissues about the joint. In this regard it should be remembered that the musculo-spiral nerve and its branches descend obliquely between the supinator longus and the brachialis anticus on the outer side of the elbow, and that the ulnar nerve follows an almost vertical course and passes directly behind the prominent internal epicondyle. The external incision is best made behind the musculo-spiral, and the internal incision slightly anterior to the ulnar nerve and posterior to the brachial artery and median nerve. If the elbow is approached through either of the above incisions the median nerve will not be in the field of operation.

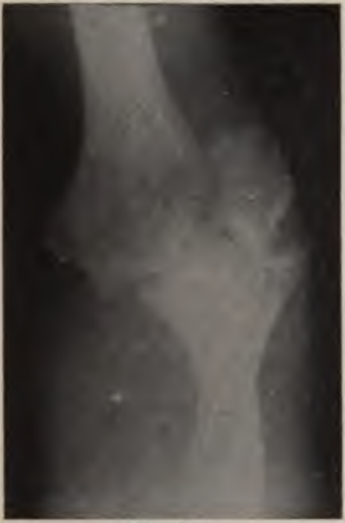


Fig. 218.

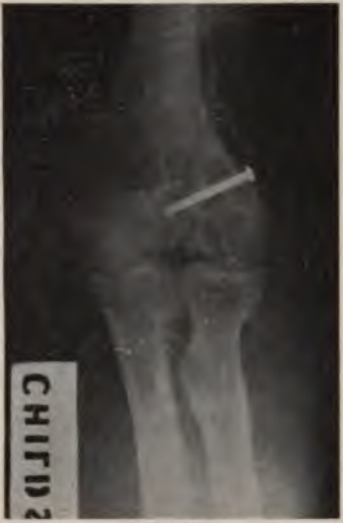


Fig. 219.

Fig. 218.—Vertical fracture of lower end of humerus. Capitellum included in fragment which is displaced downward and rotated. When an attempt is made to flex arm the edge of the fragment threatens to penetrate the skin. Fragment nailed in position at operation and fracture treated in a position of semiflexion. X-ray by H. G. Stover.

Fig. 219.—Same case five years later showing nail in place, fragment in reduction and carrying angle restored. Note the callus at upper end of fracture. Nail has not loosened and bony tissue next to nail shows no changes. Restoration of function complete. Injured member as useful and strong as opposite arm. X-ray by S. B. Childs.

After the bone has been exposed an analysis of the line or lines of fracture should be made, together with a consideration of the forces preventing reduction. The points of advantage for the placing of fixation materials are determined and the fragments reduced. A single nail will sometimes accomplish all that is required (see Fig. 219), while in other cases it will tax the ingenuity of the most capable to secure the fragments. A T-fracture may sometimes be securely held by a through and through wire, while in other instances a circular wire may be made to bind two or more fragments together. In comminuted conditions it may be possible to secure one or more large fragments to the shaft, or to bind the fragments of the lower end of the bone together by a wire above the condyles, and then accomplish the balance of reduction by acute flexion. While the bone is exposed the elbow should be carried through flexion and extension to determine the position which tends least to displace the fragments, and this position should be maintained in the after-treatment. Care should be taken not to enter either the olecranon or coronoid fossa with nail or wire, as this may be an obstacle to flexion or extension after recovery. Provision for the escape of blood and exudates should be made by leaving a small drain of silk worm gut, which is to be removed in from twenty-four to forty-eight hours.

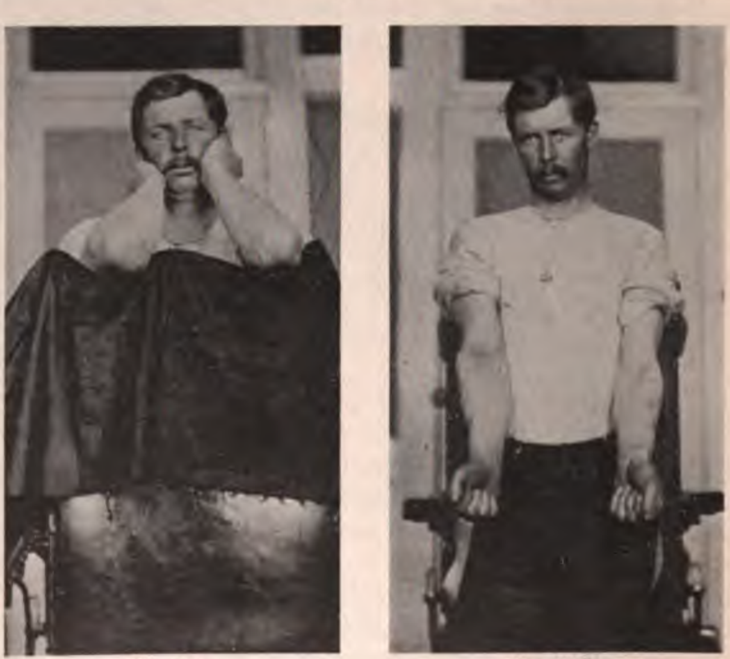


Fig. 220. Fig. 221.

Figs. 220 and 221.—Same case as seen in Figs. 218 and 219 showing range of motion at elbows and normal carrying angle. Note the normal relations of the three bony prominences when the elbows are fully flexed.

The lower end of the humerus not infrequently presents conditions of fracture as difficult to handle as any other bone in the body.

After-Treatment.—During the early part of the after-treatment the arm should be most carefully watched to avoid constriction. The dressings should be inspected at least daily to see that they remain in proper position. The axilla and bend of the elbow are points likely to show irritation of the skin and require special attention. If a posterior splint is employed the point of the elbow may need special padding to avoid undue pressure. If acute flexion is the position holding the fragments in reduction it should be increased as the swelling subsides and the danger of constriction grows less.

The production and ossification of the callus is rapid about the elbow, and passive motion and massage should be begun at the earliest possible moment consistent with immobilization of the fragments. Gentle massage may be begun soon after the subsidence of the traumatic reaction provided care is taken to avoid disturbing the fragments. Gentle passive motion may be instituted in most cases at the end of from three to five weeks according to the age of the patient. Certain cautions should be noted, however, as much harm may be done by injudicious motion. The movements should be most guarded and gentle when first begun, and the condyles should be under touch of the surgeon to see that movement of the lower fragment is not produced. Motion should in no case be carried far enough to produce pain, which may be taken as an indication that more harm than good is being done. Many surgeons prefer to delay passive motion until union is firm (four to six weeks or even later) and then if necessary the adhesions of the joint may be broken up under anesthesia. In some cases it will be necessary to anesthetize the patient a number of times, at intervals of a week or ten days, to keep the joint surfaces free until they are thoroughly healed. During the intervals the elbow is immobilized to allow the accompanying traumatic inflammation to subside. Such a procedure is tedious to both patient and surgeon but the subsequent results usually more than compensate for the additional trouble.

The arm should be watched most carefully during the first ten days to avoid constriction on the one hand and loosening of the splints on the other. Strangulation of the limb is more likely to occur when the arm is maintained in a position of acute flexion, while slipping of the splints is most often seen in positions between semi-flexion and extension. An arm should never be bandaged in a more or less extended position and then flexed, as constriction at the elbow is sure to take place. The plaster cast is a most dangerous dressing, especially if employed in the early part of the after-treatment. Its rigidity does not allow for the swelling of the member and may be followed by damaging constriction and Volkmann's contracture. When the internal or external angular splint is used it should be fixed with adhesive plaster in at least three places as shown in Fig. 214. If doubt exist as to the progress of union an X-ray plate should be taken. If the callus is heavy enough to throw a shadow it will usually be safe to employ passive motion.

The removal of the splints or dressings should be gradual; that is, they should be removed for an hour or two each day, gradually increasing the time until they are permanently removed at the end of a week. A sling should be used for some time following removal of the splints. Exercise is to be gradually instituted, taking as a guide the fatigue produced. There should be no sense of fatigue after half to three quarters of an hour following exercise. It should be remembered that the most valuable and useful part of the function of the elbow joint lies in the range of motion included between acute flexion and semi-flexion.

Prognosis.—The prognosis in fractures of the lower end of the humerus varies with the age of the patient, the severity of the lesion and whether or not the fracture enters the joint. Loss of motion in the elbow has been an unfortunately common sequel to fractures in this region, but with the advent of improved treatment, especially the open method, the number of cases of stiff elbow is being materially reduced. If the usual case of fracture of the lower end of the humerus is treated by the open method, the fragments accurately reduced, internal fixation employed and early passive motion instituted, the result will almost invariably be a functionally perfect joint without deformity. The prognosis is of course equally good in cases in which accurate reduction can be accomplished without operation, but the X-ray is continually demonstrating the fact that these cases are less numerous than was formerly supposed.

Surprisingly good function often follows these fractures in children, even when deformity and non-union are present. Disturbances in the longitudinal growth of the bone in epiphyseal separations are very unusual, being seen only in instances in which a portion or part of the epiphysis is widely separated from the diaphysis. The bad prognosis so frequently given in text-books is based on the frequency of incomplete reduction and the common practice of prolonged immobilization.

For the surgeon's protection, however, he should be quite guarded in the forecast given the patient or his family even when the case is uncomplicated. One never knows what complications may arise during the course of the case, and it has not uncommonly happened that the surgeon found that he had to deal with the exceptional case after a most favorable prognosis had been given. The outlook in compound cases is of course worse, yet if the principles laid down in the chapter on "The Treatment of Compound Fractures" (page 789) are followed out a large percentage of these open cases may be made to result as favorably as simple fractures in this region.

The unfavorable results following fractures of the lower end of the humerus are: Volkmann's contracture, flail-elbow resulting from non-union; cubitus varus, cubitus valgus, backward displacement of the lower fragment, and loss of motion varying in different cases from a solid ankylosis to a slight restriction of either complete flexion or extension. Volkmann's contracture is a most disabling condition notwithstanding the fact that some improvement may follow operation to liberate the nerves. This complication will not develop unless the arm has been unduly constricted by the dressings during the after-treatment. A flail-elbow will not follow if accurate reduction has been accomplished and, when present, may be corrected by a secondary operation. Cubitus varus and valgus are not as a rule productive of much disability. When pronounced, however, they may materially weaken the elbow and render the patient conspicuous on account of the deformity. Complete loss of motion in the elbow is rare. Loss of complete extension or acute flexion is common, though the disturbance in function is usually so slight as to be unnoticed by the patient. Sixty degrees of motion at the elbow will give the patient a serviceable joint even though the action is much less than the normal range of motion. The sooner the fracture is reduced the less marked will be the traumatic reaction.

In compound suppurating cases the outlook is of course gloomy, especially when the fracture enters the joint cavity, yet it should not be forgotten that union may be obtained even in the presence of pus if free drainage is provided for. Much may be done in ankylosis by arthroclasia and arthroplasty.

CHAPTER X.

DISLOCATIONS OF THE ELBOW.

Under this heading are included only the luxations in which both bones of the forearm are displaced on the humerus. Luxations of either the ulna or radius alone will be taken up later.

Surgical Anatomy.—Much that has been stated under the heading of "Surgical Anatomy" in "Fractures of the Lower End of the Humerus" applies equally well in dislocations of the elbow (see page 120).

The bones entering into the formation of the elbow joint are the humerus above, and the radius and ulna below. The articulation between the humerus and ulna is of the ginglymus or hinge type. The articulation between the humerus and the head of the radius is of the ball-and-socket type, though the attachments existing between the bones of the forarm necessitate the radius following the ulna in flexion and extension of the forearm. The strength of the elbow, especially its lateral stability, depends on the humero-ulnar articu-

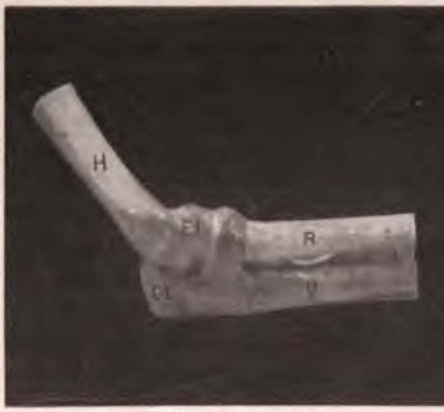


Fig. 222.

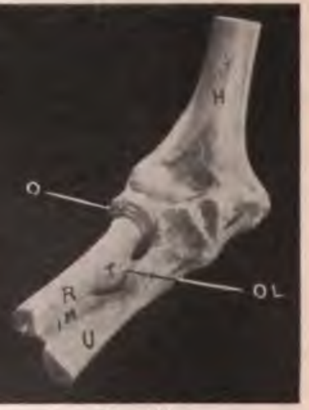


Fig. 223.

Fig. 222.—Ligaments of elbow from radial side. *H.*, Humerus; *R.*, Radius; *U.*, Ulna; *O.L.*, Olecranon; *E.L.*, External lateral ligament; *O.*, Orbicular ligament.

Fig. 223.—Another view of the elbow. *T.*, Tuberosity of radius; *O.L.*, Oblique ligament; *O.*, Orbicular ligament.

lation and the lateral ligaments of the elbow. The internal lateral ligament consists of two divergent bands arising from the epitrochlea; the anterior band is attached to the inner side of the coronoid and the posterior band to the inner side of the olecranon, posteriorly. The external lateral ligament is similar to the internal; it is composed of two bands arising from the epicondyle. The anterior band passes downward and forward, blends with the orbicular ligament and is attached just in front of the lesser sigmoid cavity of the ulna. The posterior band blends with the orbicular ligament, passes behind the head of the radius and is attached behind the lesser sigmoid cavity. Extension of the elbow is limited by the anterior portion of the capsule, by the anterior bands of the lateral ligaments, by the tip of the olecranon coming in contact with the bottom of the olecranon fossa, and by the tension of the biceps and brachialis anticus. Flexion is limited by the arm coming in contact with the forearm, by tension on the posterior bands of the lateral ligament, and by seating of the coronoid process in the fossa of the same name. In the usual dislocation of the elbow the orbicular ligament remains intact and the radius is displaced with the ulna. The overwhelming majority of luxations of the elbow are of the backward type and are usually produced by forced hyperextension of the joint. If the ligaments prove stronger than the lower end of the humerus, fracture is the result; if not, luxation of the elbow is produced.

The bones of the forearm may be displaced in any direction, and accordingly the luxations occurring at the elbow have been classified as follows:

Backward (common).
Outward (next in order of frequency).
Inward (rare).
Forward (rare).
Divergent, antero-posteriorly (very rare).
Divergent, laterally (very rare).

Dislocation of the bones of the forearm from the humerus must of necessity be accompanied by extensive ligamentary tearing; the lateral ligaments being the ones usually suffering most extensive laceration. It not infrequently happens that a given ligament is stronger than the bone to which it is attached, and accordingly fracture is not an uncommon complication of dislocations of the elbow. The external condyle may be broken off and the fragment remain attached to and displaced with the radius. The epitrochlea is even more commonly avulsed and displaced by the action of the internal lateral ligament, and the detached fragment may act as an obstacle to reduction by becoming interposed between the trochlea and sigmoid cavity. The periosteum is probably always more or less stripped up from the posterior surface of the humerus, the pull being transmitted through the posterior ligament. When the ligament proves stronger than the bone the olecranon process may be fractured. This stripping up of the periosteum accounts for the deposit of bony tissue seen on the posterior surface of the humerus following backward luxations. Fracture of the radial head or neck may occur as a complication in luxations of the elbow, and fracture of the shaft or lower end of the bone has been noted. Probably the most common fracture occurring in dislocations of this joint is that of the coronoid. This process is broken off as the ulna is driven backward across the trochlea. The brachialis anticus is attached to the anterior surface of the coronoid, and when the fragment is displaced upward it is usually tilted so the anterior surface looks more nearly in an upward direction. Instances of this complicating fracture are shown in Figs. 240 to 244.

Injuries to vessels and nerves are fortunately seldom seen except in the most severe compound luxations. The median and musculospiral nerves are known to have been injured by the lower end of the humerus projecting into the bend of the elbow anteriorly. The ulnar nerve may be injured as it passes behind the epitrochlea, especially when this process is fractured or in the rare anterior luxation. Cases of laceration of the brachial artery are on record, but are extremely rare.

Hyperextension, forced abduction or adduction, and wrenches and twists of the forearm are the types of violence usually responsible for luxations of the elbow.

Symptoms.—Pain, tenderness, loss of function, restricted mobility and swelling of the parts about the elbow are symptoms common to all types of luxation of this joint. The patient is unable to use the forearm following injury (usually a fall on the outstretched hand) and complains of pain which is greatly increased on motion. The elbow is usually restricted in motion, especially flexion, but there may be some abnormal lateral mobility. There is no true crepitus unless fracture complicates the luxation. The degree of swelling is variable though it usually appears promptly and is frequently pronounced. The relation of the three bony prominences is disturbed (except in anterior luxation with fracture of the ulna) and on examination the olecranon will be found to be the displaced element. The displacement of the ulna varies with the type of luxation.

The attitude of the patient is suggestive of the lesion, though by no means as characteristic as in luxations of the shoulder. In the posterior luxations the injured member is usually allowed to hang uselessly at the side, or is rested on some convenient support such as a table. In the lateral or forward dislocations with fracture, the injured arm is, as a rule, supported by the opposite hand and the patient is reluctant to release it for examination. Deformity is the symptom which varies most in the different types of luxation.

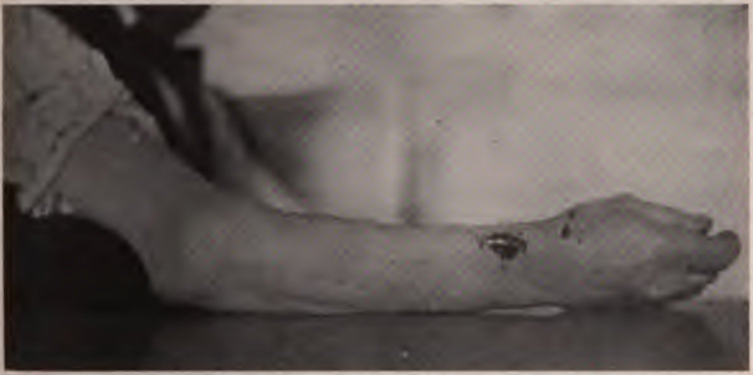


Fig. 224.—Simple backward dislocation of elbow a few minutes after the accident.

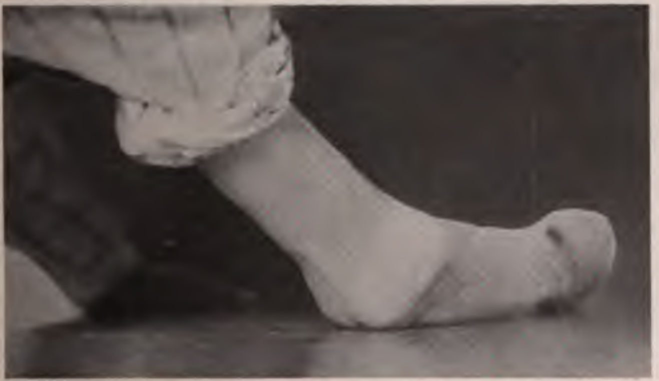


Fig. 225.—Same case seen from behind.

The posterior variety is by far the most common dislocation at the elbow, and is well represented by the cases shown in Figs 224 to 230. The forearm is usually in a position between complete extension and semiflexion, and motion in either direction, beyond a few degrees, is painful and restricted both by spasm of the muscles and the disturbed mechanism of the joint itself. The olecranon is raised above its normal level, and more prominent than it should be. The tendon of the triceps stands out prominently, and the forearm is shortened. Inspection of the forearm at the elbow often shows that it is rotated slightly inward and displaced outward (see Fig. 230). This rotation is due to the fact that the inner lip of the trochlea projects downward further than does the external lip, and thus pushes the ulna to the radial side, when the projection is no longer received in the cavity of the sigmoid. The lateral stability of the elbow is not, as a rule, so much impaired as in fractures of the lower end of the humerus. In palpating the elbow in backward dislocations, the fingers may be pressed into the empty sigmoid cavity of the ulna and the thumb may be placed in the shallow depression on the head of the radius, as shown in Fig. 229. The joint is painful as long as it is out of position, yet the pain is only intense when the elbow is moved. This displacement is probably not as painful as dislocation of the shoulder. The coronoid process

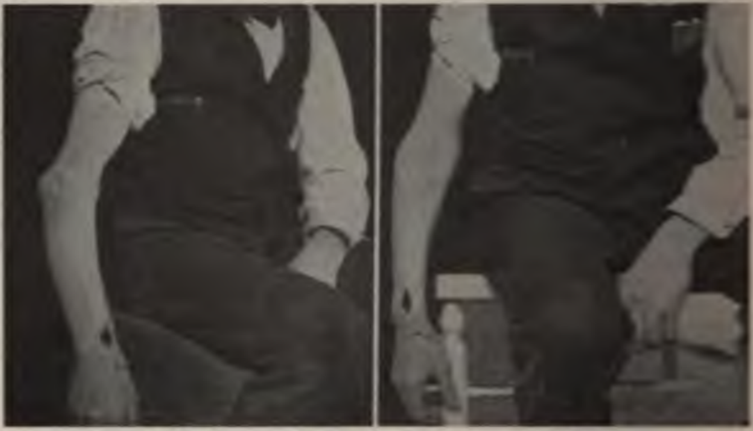


Fig. 226. Fig. 227.

Figs. 226 and 227.—Additional views of the same case. Note the prominence of the triceps tendon in the picture to the left and the gun-stock deformity in the picture to the right. This picture calls attention to the fact that gun-stock deformity may exist in dislocations of the elbow as well as in fractures of the lower end of the humerus.

(unless broken off) rests behind the trochlea, and if the elbow is much extended it enters the olecranon fossa. The head of the radius lies behind the capitellum.

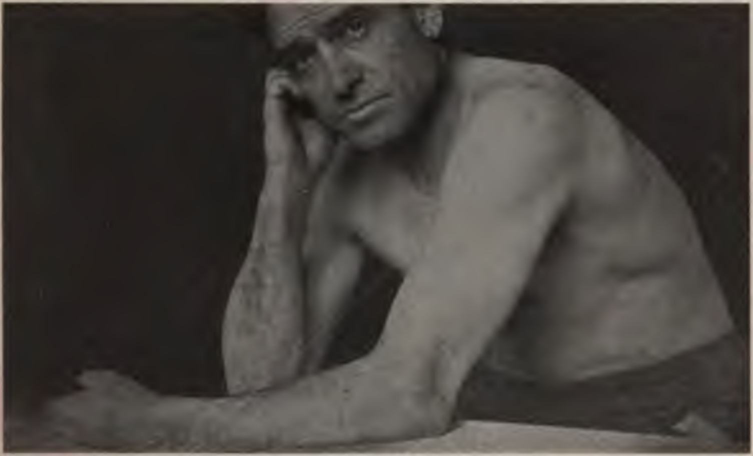


Fig. 228.

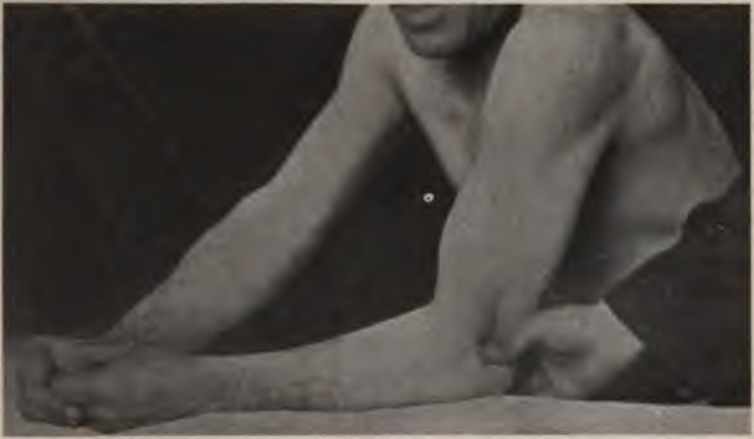


Fig. 229.

Figs. 228 and 229.—Simple backward dislocation of the elbow about half an hour following the accident. Note the depression or dimple behind the elbow which is characteristic of this condition. Compare this case with Figs. 188, 189, 198 and 199. Fig. 229 shows palpation of same case. The tip of the thumb rests in the depression on top of the head of the radius. The sigmoid cavity of the ulna lies between the thumb and index finger of the examining hand and is felt to be empty. The leverage of the triceps is increased while that of the biceps is lessened and hence the position of least pain is greater than semiflexion.

Lateral dislocations of the elbow may be divided into internal and external. *External lateral dislocations* may be complete or incomplete, and there may or may not be an element of rotation present, as well as the lateral displacement. The incomplete external dislocation is the most common of the lateral displacements, but is much

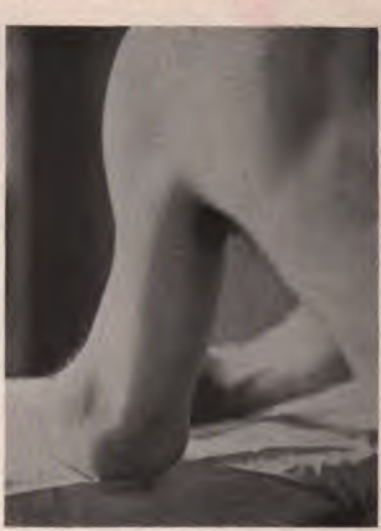


Fig. 230.—In backward luxations there is often a slight displacement of the ulna to the outer side which can be best appreciated by looking at the elbow from behind. This element in the deformity is caused by the inner lip of the trochlea which is more prominent than the outer. Note the prominence of the triceps tendon and the depressions on either side of it.

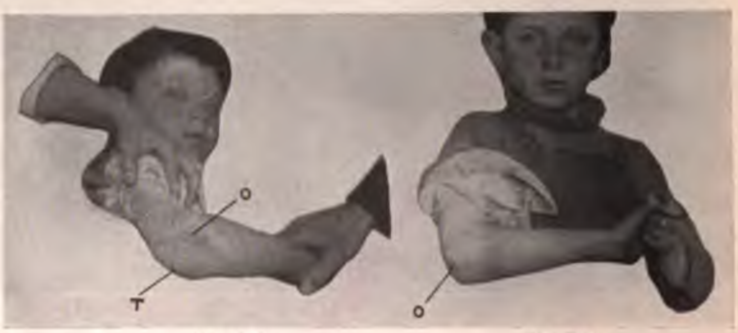


Fig. 231. Fig. 232.

Figs. 231 and 232.—Outward dislocation of the elbow. The upper ends of the radius and ulna have been displaced outward and the forearm rotated so that the radius lies above the ulna. *O.*, the position of the olecranon. *T.*, the inner edge of the trochlea. Picture taken a few minutes following accident and the swelling is only slight.

less frequently seen than the backward luxation just described. There is no hard and fast line between posterior and external lateral dislocations, which point should be remembered in dealing with luxations of the elbow. Cases are seen with backward dislocation accompanied by an external displacement, and cases of external dislocation are seen with an element of backward displacement, and it is difficult, in many cases, to say which element of the condition is more prominent. An arbitrary dividing line is considered by some to be the position of the coronoid; if this process lies anterior to the trochlea the dislocation is lateral, but if it lies behind the trochlea it is posterior. Such a division makes the conditions fit the classification, rather than the classification fitting the condition.

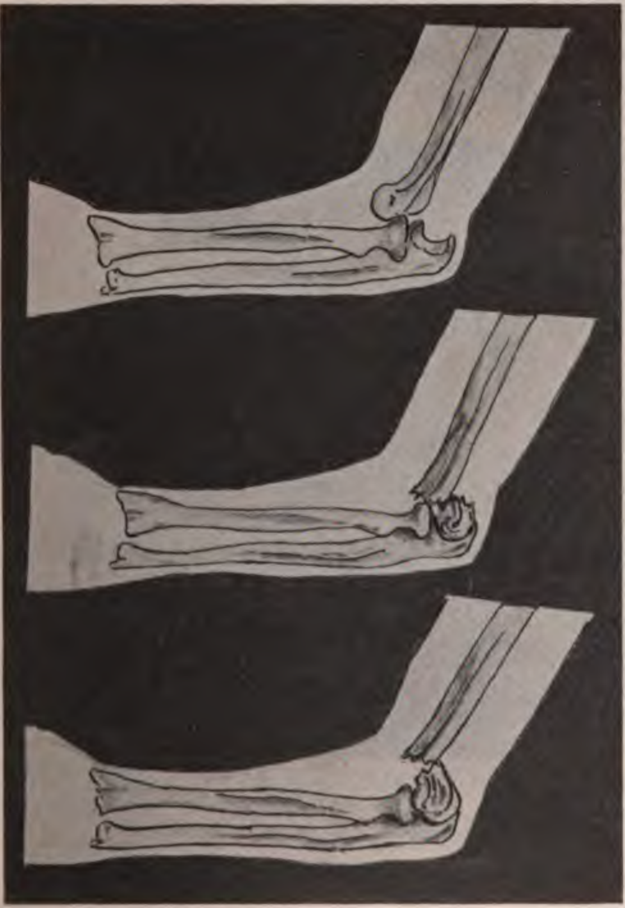
The external lateral dislocation is usually incomplete, the sigmoid of the ulna embraces the capitellum, and the head of the radius stands out externally; more frequently the head of the radius is raised above the level of the ulna and lies on, or close to, the epicondyle. This elevation of the head of the radius produces an inward rotation of the forearm, and the condition is spoken of as lateral dislocation with rotation or pronation. In other instances we find a complete external displacement of the bones of the forearm. In such cases the ulna has been carried further outward and rests on the surface of the epicondyle; the radius may lie external to the ulna or above it, and accordingly we have complete external dislocation with or without rotation or pronation of the forearm. The ligaments are more or less torn according to the degree of displacement, but only in rare instances may the injury to the ligaments (especially the anterior and internal) be considered slight. It is not uncommon to find the internal lateral ligament stronger than the bone to which it is attached, which accounts for the occasional fracture and outward displacement of the epitrochlea. This fragment may act as an obstacle to reduction by becoming interposed between the articular surfaces of the ulna and humerus. The elbow will be found broadened according to the degree of displacement. The relation of the three bony prominences is disturbed. The olecranon will be felt external to its normal position and the head of the radius located external to the epicondyle. The internal condyle is subcutaneous and very prominent, and the inner edge of the trochlea may be palpated below it, just under the skin. The epicondyle is not palpable because of the external displacement of the bones of the forearm. One not accustomed to these conditions of the elbow may become confused in attempting to identify the three bony prominences, and a diagnosis of fracture in such cases is common, when none really exists.

Internal lateral dislocation of the elbow is quite rare and only seen in the incomplete variety. The sigmoid of the ulna embraces the internal epicondyle, while the head of the radius is displaced more or less inward onto the outer portion of the trochlea. The forearm is inclined to a position of supination, and the olecranon is out of relation with the condyles of the humerus. Complications in lateral dislocations are extremely rare, and consist for the most part in fracture of the internal epicondyle; fracture of the external condyle has been reported.

Forward dislocation of the elbow is extremely rare and seems to be secondary to fracture of the olecranon. Fracture of this process, at the bottom of the sigmoid cavity, may result in the distal fragment of the ulna being driven upward in front of the humerus by the same force that produced the fracture. Complete anterior dislocation, without fracture of the olecranon, is so rare that it had better be considered an anomaly. The fractured olecranon may be recognized by palpation and the abnormally high position of the upper part of the forearm, and its change in axis may be determined without difficulty (see Fig. 239). When the olecranon is not fractured it either lies in front of the lower end of the humerus or (in the incomplete form) the end of the process rests on the trochlea, the lateral ligaments having suffered extensive laceration.

Divergent dislocations of the elbow are very rare indeed, being usually the result of great trauma. They are sometimes seen in falls from a height and in severe machinery accidents. One reason for the rarity of these dislocations is that the arm is seldom caught in just such a manner as to tear both the heavy orbicular ligament and the interosseous membrane, and the force so directed as to displace the bones in different directions. There are two forms of divergent dislocation—antero-posterior and lateral. In the *antero-posterior* the radius lies anterior to the humerus, and the ulna behind it. The posterior aspect of the elbow resembles quite closely the simple posterior variety of dislocation, the point of differentiation being the presence of the head of the radius in front of the elbow. The *lateral variety* is so rare that few cases have been reported. The ulna lies to the inner side of the humerus, while the radius is displaced externally, and the elbow is accordingly increased in breadth to nearly twice that of normal.

The symptoms produced by injury to nerves or vessels will depend on which of these structures has been damaged. The paralyses or disturbances in circulation are the same as follow injury to the nerves and vessels of the upper extremity from causes other than dislocation of the elbow.



Figs. 233, 234 and 235.—Diagrams showing the bony relations in the three most common injuries at the elbow. The upper diagram is of a posterior dislocation. Note the empty sigmoid cavity. The middle drawing is of a dia-condylar fracture while the lower is of a supracondylar fracture. There is no hard and fast line between the supra- and dia-condylar fractures yet the terms are used to indicate the level of the break.

Diagnosis.—The recognition and differentiation of the various types of luxation of the elbow are made on the symptoms just described. In establishing a diagnosis of dislocation of the elbow the surgeon must keep in mind—first, the bony lesions which are most commonly mistaken for luxation; second, the complicating fractures which sometimes accompany dislocations; and third, the complicating lesions of the soft tissues, such as injury to vessels and nerves. The condition most frequently confounded with dislocation is fracture or epiphyseal separation of the lower end of the humerus. In fracture of the lower end of the humerus with backward displacement, the sigmoid is not found empty and it is impossible to feel the cup-shaped depression on the head of the radius as shown in Fig. 229. The backward displacement is usually less prominent in fractures, and the deformity is, as a rule, perceptibly higher. The relation of the three bony prominences is disturbed in vertical fractures of the lower end of the humerus, in dislocations of the elbow and in fractures of the olecranon, but not in transverse fractures of the lower end of the humerus. (See Figs. 233 to 235 and compare the deformities.) Dislocations of the upper end of the ulna alone are differentiated from luxations

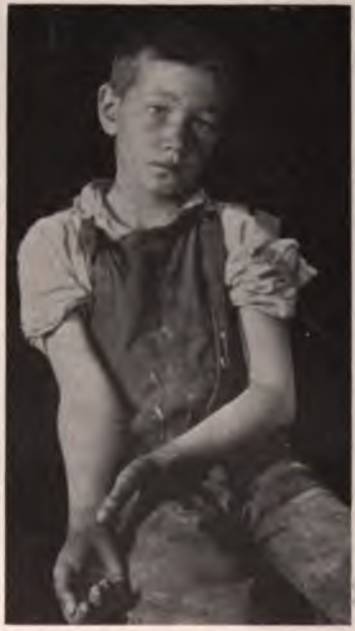


Fig. 236.—Case of simple sprain of the elbow twenty-four hours after the accident. Note the swelling which is as great as is seen following fracture or dislocation and materially interferes with examination and diagnosis. Note, however, that there is no ecchymosis which is so common in fractures, after the first twelve or twenty-four hours.

of the elbow by the position of the head of the radius which remains in its proper relation with the capitellum.

To avoid mistakes it is well to identify the ulna at its lower end and trace the posterior subcutaneous border up to the olecranon; the head of the radius may next be identified and rotated by supinating and pronating the forearm. After these two points have been positively identified there will usually be little difficulty in recognizing the other landmarks of the elbow. When the case is seen early a tentative diagnosis can, as a rule, be made by inspection alone, but if first seen after swelling has developed it may be quite difficult to examine and determine the condition.

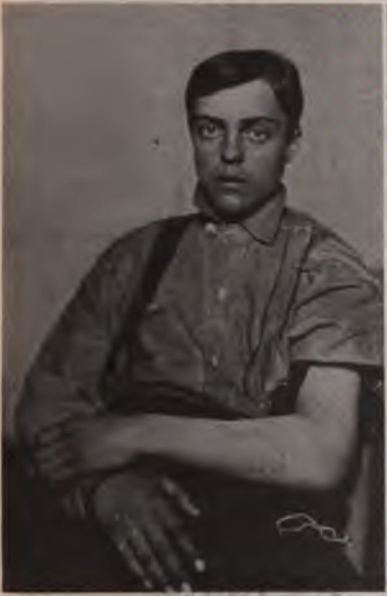


Fig. 237.

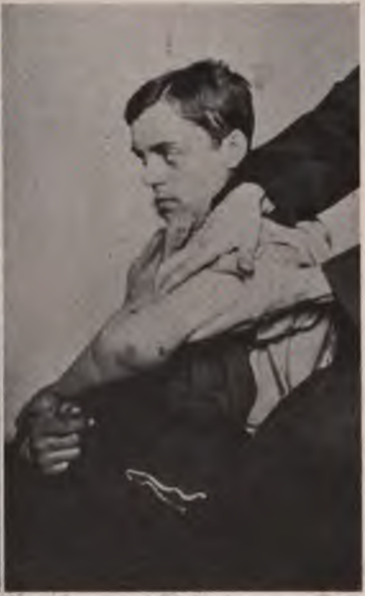


Fig. 238.

Fig. 237.—Case of lateral dislocation of the elbow twenty-four hours after injury and reduction. Note the swelling about the elbow.

Fig. 238.—Same case after palpation of three bony prominences and marking same with ink.

Gentle, firm and continued pressure with the fingers in the region of the condyles and olecranon will usually displace the fluids within the tissues sufficiently to allow the surgeon to determine the positions and conditions of the three bony prominences. An anesthetic is often advisable if the traumatic reaction is pronounced at the time of the examination. An even better procedure under these circumstances (provided the deformity is not great and the X-ray is promptly available) is to leave the parts undisturbed and determine the nature of the injury from a Röntgenogram.

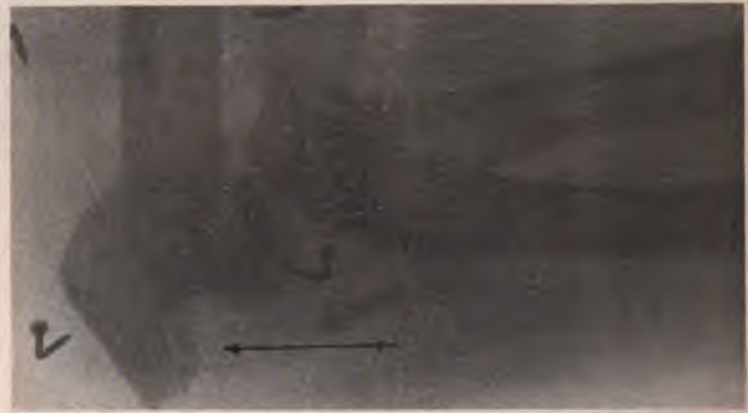


Fig. 239.—Anterior luxation of the elbow with fracture of the olecranon. (Small nails seen in plate are in splint.)

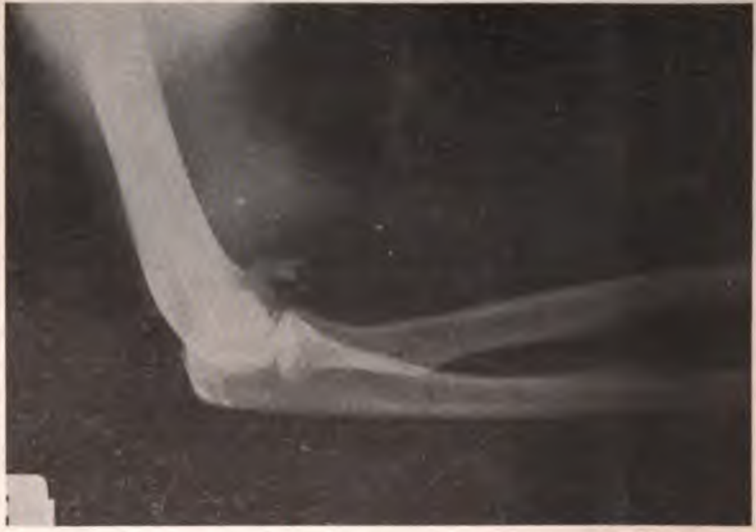


Fig. 240.—A not uncommon complication of backward dislocations of the elbow. The coronoid process has been broken off and is displaced upward by the brachialis anticus. This muscle is inserted into the anterior surface as well as the tip of the process which accounts for the tipping of the fragment as it is pulled upward.

Fracture of the coronoid is often difficult to recognize because of the swelling. It is frequently impossible to palpate the detached particle of bone, and the fact that the fragment is usually displaced upward prevents crepitus.

Complications are fortunately rare yet they do occasionally occur and should, if possible, be recognized before reduction. The diagnosis of these conditions is often made only after reduction has been attempted or accomplished, and many cases would go unrecognized if it were not for the X-ray. The condition of the reflexes and the circulation below the level of the lesion should be determined both before and after reduction. Recurrence of deformity following reduction is suggestive of fracture of the lower end of the humerus or of the coronoid process of the ulna.

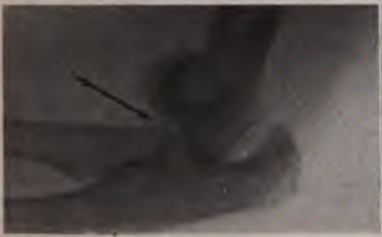


Fig. 241.

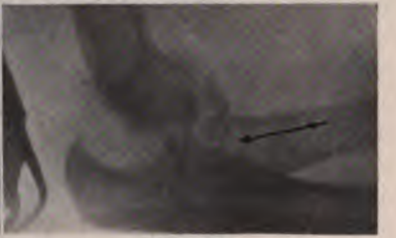


Fig. 242.

Fig. 241.—Backward luxation fracture of the tip of the coronoid process.
Fig. 242.—Backward luxation with comminuted fracture of coronoid process.

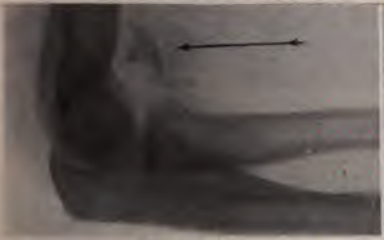


Fig. 243.

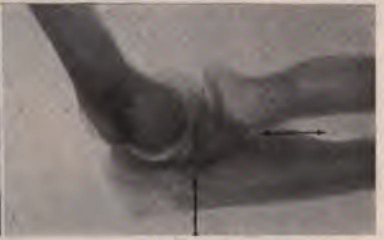


Fig. 244.

Fig. 243.—Large fragment of coronoid displaced upward by action of biceps. Fracture result of backward luxation of elbow.

Fig. 244.—Fracture of coronoid with only slight displacement. Result of backward luxation of elbow.

Treatment.—The treatment of dislocations of the elbow consists in returning the ulna and radius to their normal relations with the humerus, and immobilizing the elbow for a period sufficiently long to allow complete healing of the ligaments. The case should be attended as soon following the accident as possible. The longer the luxation exists the more difficult will be the diagnosis, the more painful the parts and the more pronounced the secondary traumatic reaction. Reduction of the dislocation is usually not difficult, and according to the most common method, consists (for backward luxations) in traction and counter-traction with hyper-extension of the joint followed by flexion. The arm is firmly grasped above the elbow with one hand while the other makes traction from the wrist; during this traction the forearm is somewhat hyper-extended to allow the coronoid to clear the trochlea, after which the forearm is flexed and reduction is complete. The ligaments are usually torn

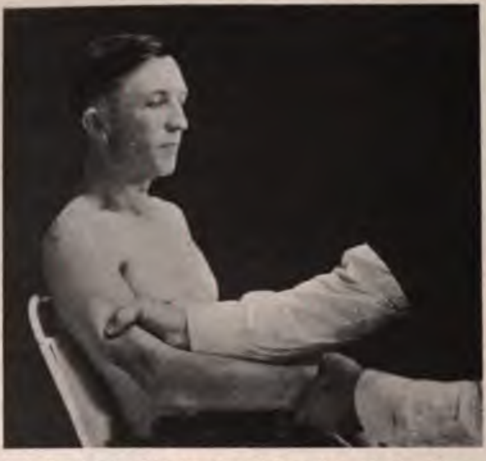


Fig. 245.—Method of reducing backward luxation of the elbow. Traction on the forearm at the wrist with counter-traction with the opposite hand on the arm. A greater degree of extension is often necessary to help the coronoid to clear the trochlea.

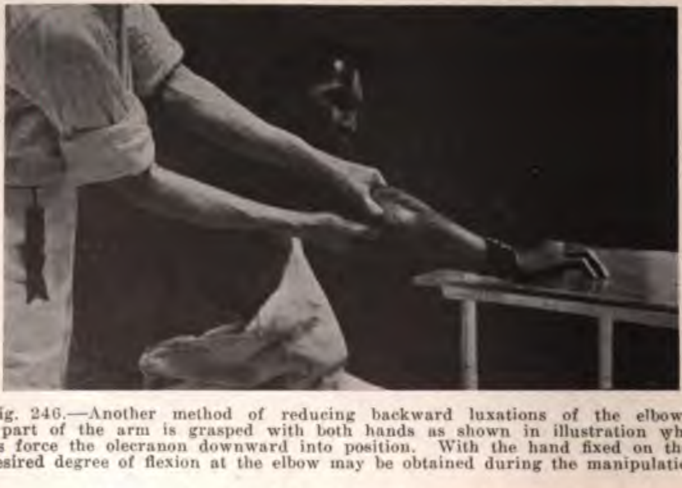


Fig. 246.—Another method of reducing backward luxations of the elbow. The lower part of the arm is grasped with both hands as shown in illustration while the thumbs force the olecranon downward into position. With the hand fixed on the table any desired degree of flexion at the elbow may be obtained during the manipulation.

to such an extent that they offer little resistance to reduction, but the muscles, especially in well developed persons, may as a result of spasm, render reduction extremely difficult. A method of reduction, particularly adapted to children, consists in forcing the olecranon into place with the thumbs while the fingers fix the arm above the elbow as shown in Fig. 246. By having the patient's hand resting on a table flexion and extension may be controlled by raising or lowering the elbow during the manipulation, thus helping the coronoid to clear the trochlea. Still another method is one in which the joint surfaces are separated and flexion of the elbow accomplished over the operator's knee. Reduction may also be accomplished by means of continuous traction with weights, but the first method described will be found as satisfactory as any in the average case of posterior luxation.

The muscles offer the chief obstacle to reduction and accordingly the use of an anesthetic will render difficult cases easy. The ligaments are already much torn and we should avoid manipulations which will subject them to further injury; this point should be kept well in mind when using an anesthetic, as the joint, under such conditions, is no longer protected by the action of the muscles. When the bones are displaced outward further than is caused by the internal lip of the trochlea (see Figs. 231 and 232), they should be converted into a simple backward dislocation before reduction is attempted. The less force used the better, and in a given case it is often preferable to try different methods with moderate force, before using any particular one with much force. There is probably no method, in backward dislocations of the elbow, which meets the indications as scientifically as does Kocher's in reduction of anterior luxations of the shoulder, yet the ones in use are effective and though not ideal are at least satisfactory.

In *reducing an outward luxation* it is of the greatest advantage to have an assistant fix the lower end of the humerus, thus affording the surgeon a solid basis on which to force the bones of the forearm into position. Before reduction is attempted the surgeon should know whether or not rotation is present, as well as lateral displacement. With the lower end of the arm fixed, traction is made on the wrist, while the opposite hand grasps the elbow and forces the upper ends of the radius and ulna downward and inward around the lower end of the humerus. If the bones of the forearm are displaced backward as well as outward it may be advisable to accomplete, and there may or may not be an element of rotation present, as well as the lateral displacement. The incomplete external dislocation is the most common of the lateral displacements, but is much less frequently seen than the backward luxation just described. There is no hard and fast line between posterior and external lateral dislocations, which point should be remembered in dealing with

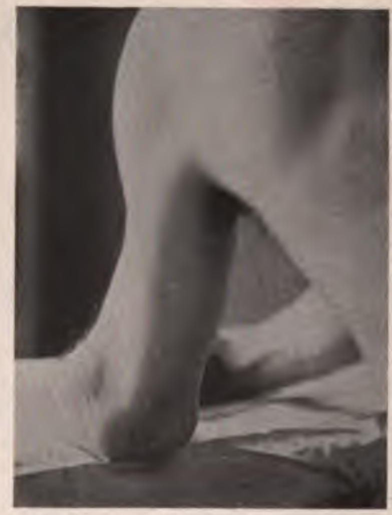


Fig. 230.—In backward luxations there is often a slight displacement of the ulna to the outer side which can be best appreciated by looking at the elbow from behind. This element in the deformity is caused by the inner lip of the trochlea which is more prominent than the outer. Note the prominence of the triceps tendon and the depressions on either side of it.

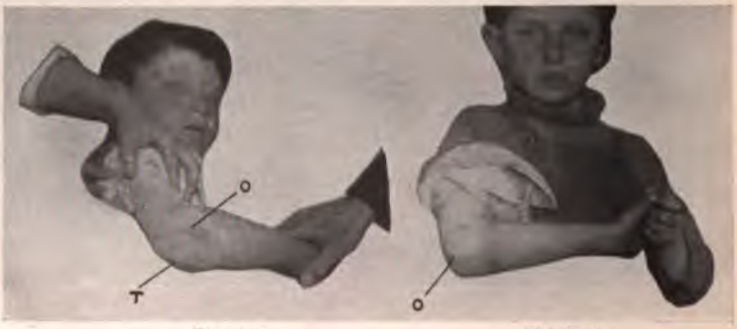


Fig. 231. Fig. 232.

Figs. 231 and 232.—Outward dislocation of the elbow. The upper ends of the radius and ulna have been displaced outward and the forearm rotated so that the radius lies above the ulna. *O.*, the position of the olecranon. *T.*, the inner edge of the trochlea. Picture taken a few minutes following accident and the swelling is only slight.

luxations of the elbow. Cases are seen with backward dislocation accompanied by an external displacement, and cases of external dislocation are seen with an element of backward displacement, and it is difficult, in many cases, to say which element of the condition is more prominent. An arbitrary dividing line is considered by some to be the position of the coronoid; if this process lies anterior to the trochlea the dislocation is lateral, but if it lies behind the trochlea it is posterior. Such a division makes the conditions fit the classification, rather than the classification fitting the condition.

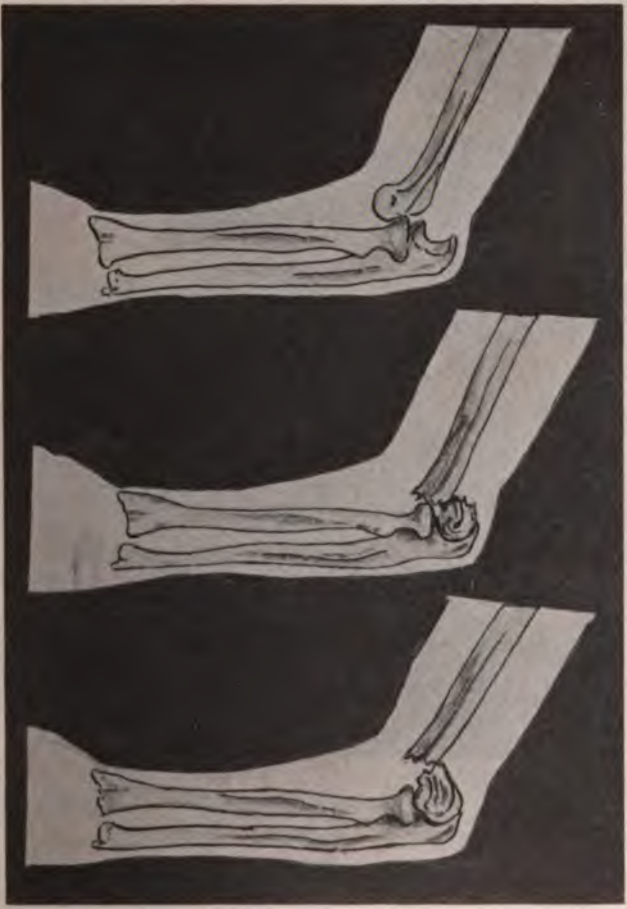
The external lateral dislocation is usually incomplete, the sigmoid of the ulna embraces the capitellum, and the head of the radius stands out externally; more frequently the head of the radius is raised above the level of the ulna and lies on, or close to, the epicondyle. This elevation of the head of the radius produces an inward rotation of the forearm, and the condition is spoken of as lateral dislocation with rotation or pronation. In other instances we find a complete external displacement of the bones of the forearm. In such cases the ulna has been carried further outward and rests on the surface of the epicondyle; the radius may lie external to the ulna or above it, and accordingly we have complete external dislocation with or without rotation or pronation of the forearm. The ligaments are more or less torn according to the degree of displacement, but only in rare instances may the injury to the ligaments (especially the anterior and internal) be considered slight. It is not uncommon to find the internal lateral ligament stronger than the bone to which it is attached, which accounts for the occasional fracture and outward displacement of the epitrochlea. This fragment may act as an obstacle to reduction by becoming interposed between the articular surfaces of the ulna and humerus. The elbow will be found broadened according to the degree of displacement. The relation of the three bony prominences is disturbed. The olecranon will be felt external to its normal position and the head of the radius located external to the epicondyle. The internal condyle is subcutaneous and very prominent, and the inner edge of the trochlea may be palpated below it, just under the skin. The epicondyle is not palpable because of the external displacement of the bones of the forearm. One not accustomed to these conditions of the elbow may become confused in attempting to identify the three bony prominences, and a diagnosis of fracture in such cases is common, when none really exists.

Internal lateral dislocation of the elbow is quite rare and only seen in the incomplete variety. The sigmoid of the ulna embraces the internal epicondyle, while the head of the radius is displaced more or less inward onto the outer portion of the trochlea. The forearm is inclined to a position of supination, and the olecranon is out of relation with the condyles of the humerus. Complications in lateral dislocations are extremely rare, and consist for the most part in fracture of the internal epicondyle; fracture of the external condyle has been reported.

Forward dislocation of the elbow is extremely rare and seems to be secondary to fracture of the olecranon. Fracture of this process, at the bottom of the sigmoid cavity, may result in the distal fragment of the ulna being driven upward in front of the humerus by the same force that produced the fracture. Complete anterior dislocation, without fracture of the olecranon, is so rare that it had better be considered an anomaly. The fractured olecranon may be recognized by palpation and the abnormally high position of the upper part of the forearm, and its change in axis may be determined without difficulty (see Fig. 239). When the olecranon is not fractured it either lies in front of the lower end of the humerus or (in the incomplete form) the end of the process rests on the trochlea, the lateral ligaments having suffered extensive laceration.

Divergent dislocations of the elbow are very rare indeed, being usually the result of great trauma. They are sometimes seen in falls from a height and in severe machinery accidents. One reason for the rarity of these dislocations is that the arm is seldom caught in just such a manner as to tear both the heavy orbicular ligament and the interosseous membrane, and the force so directed as to displace the bones in different directions. There are two forms of divergent dislocation—antero-posterior and lateral. In the *antero-posterior* the radius lies anterior to the humerus, and the ulna behind it. The posterior aspect of the elbow resembles quite closely the simple posterior variety of dislocation, the point of differentiation being the presence of the head of the radius in front of the elbow. The *lateral variety* is so rare that few cases have been reported. The ulna lies to the inner side of the humerus, while the radius is displaced externally, and the elbow is accordingly increased in breadth to nearly twice that of normal.

The symptoms produced by injury to nerves or vessels will depend on which of these structures has been damaged. The paralyses or disturbances in circulation are the same as follow injury to the nerves and vessels of the upper extremity from causes other than dislocation of the elbow.



Figs. 233, 234 and 235.—Diagrams showing the bony relations in the three most common injuries at the elbow. The upper diagram is of a posterior dislocation. Note the empty sigmoid cavity. The middle drawing is of a dia-condylar fracture while the lower is of a supracondylar fracture. There is no hard and fast line between the supra- and dia-condylar fractures yet the terms are used to indicate the level of the break.

Diagnosis.—The recognition and differentiation of the various types of luxation of the elbow are made on the symptoms just described. In establishing a diagnosis of dislocation of the elbow the surgeon must keep in mind—first, the bony lesions which are most commonly mistaken for luxation; second, the complicating fractures which sometimes accompany dislocations; and third, the complicating lesions of the soft tissues, such as injury to vessels and nerves. The condition most frequently confounded with dislocation is fracture or epiphyseal separation of the lower end of the humerus. In fracture of the lower end of the humerus with backward displacement, the sigmoid is not found empty and it is impossible to feel the cup-shaped depression on the head of the radius as shown in Fig. 229. The backward displacement is usually less prominent in fractures, and the deformity is, as a rule, perceptibly higher. The relation of the three bony prominences is disturbed in vertical fractures of the lower end of the humerus, in dislocations of the elbow and in fractures of the olecranon, but not in transverse fractures of the lower end of the humerus. (See Figs. 233 to 235 and compare the deformities.) Dislocations of the upper end of the ulna alone are differentiated from luxations

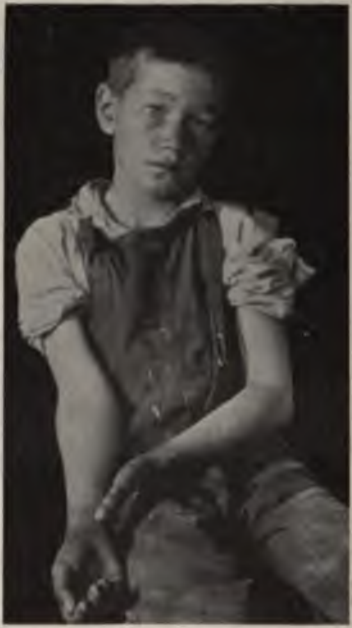


Fig. 236.—Case of simple sprain of the elbow twenty-four hours after the accident. Note the swelling which is as great as is seen following fracture or dislocation and materially interferes with examination and diagnosis. Note, however, that there is no ecchymosis which is so common in fractures, after the first twelve or twenty-four hours.

of the elbow by the position of the head of the radius which remains in its proper relation with the capitellum.

To avoid mistakes it is well to identify the ulna at its lower end and trace the posterior subcutaneous border up to the olecranon; the head of the radius may next be identified and rotated by supinating and pronating the forearm. After these two points have been positively identified there will usually be little difficulty in recognizing the other landmarks of the elbow. When the case is seen early a tentative diagnosis can, as a rule, be made by inspection alone, but if first seen after swelling has developed it may be quite difficult to examine and determine the condition.

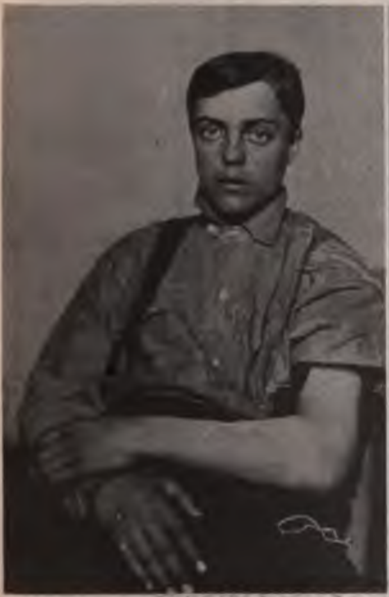


Fig. 237.

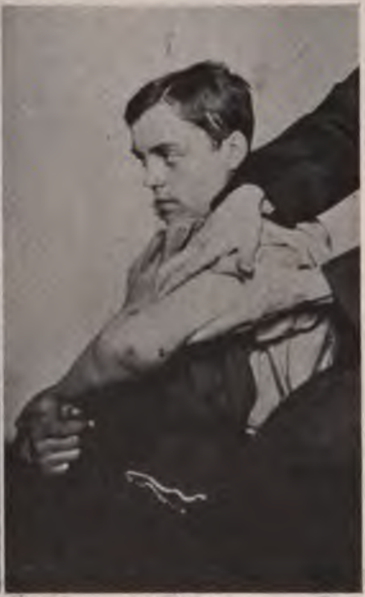


Fig. 238.

Fig. 237.—Case of lateral dislocation of the elbow twenty-four hours after injury and reduction. Note the swelling about the elbow.

Fig. 238.—Same case after palpation of three bony prominences and marking same with ink.

Gentle, firm and continued pressure with the fingers in the region of the condyles and olecranon will usually displace the fluids within the tissues sufficiently to allow the surgeon to determine the positions and conditions of the three bony prominences. An anesthetic is often advisable if the traumatic reaction is pronounced at the time of the examination. An even better procedure under these circumstances (provided the deformity is not great and the X-ray is promptly available) is to leave the parts undisturbed and determine the nature of the injury from a Röntgenogram.

Fig. 239.—Anterior luxation of the elbow with fracture of the olecranon. (Small nails seen in plate are in splint.)

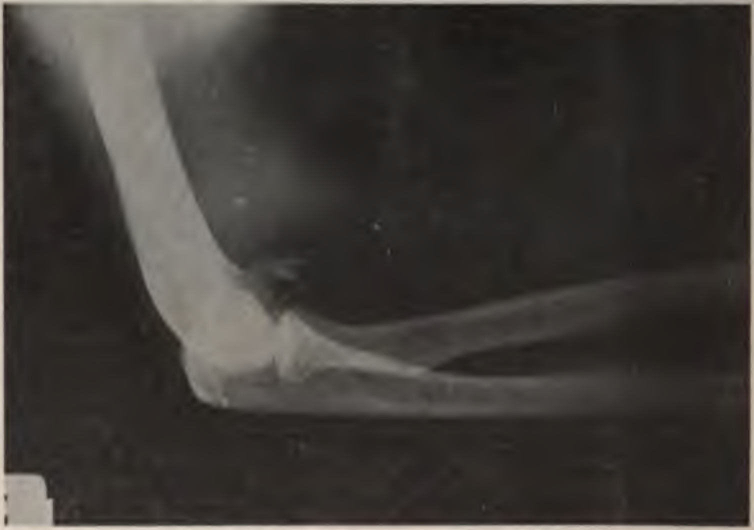


Fig. 240.—A not uncommon complication of backward dislocations of the elbow. The coronoid process has been broken off and is displaced upward by the brachialis anticus. This muscle is inserted into the anterior surface as well as the tip of the process which accounts for the tipping of the fragment as it is pulled upward.

Fracture of the coronoid is often difficult to recognize because of the swelling. It is frequently impossible to palpate the detached particle of bone, and the fact that the fragment is usually displaced upward prevents crepitus.

Complications are fortunately rare yet they do occasionally occur and should, if possible, be recognized before reduction. The diagnosis of these conditions is often made only after reduction has been attempted or accomplished, and many cases would go unrecognized if it were not for the X-ray. The condition of the reflexes and the circulation below the level of the lesion should be determined both before and after reduction. Recurrence of deformity following reduction is suggestive of fracture of the lower end of the humerus or of the coronoid process of the ulna.

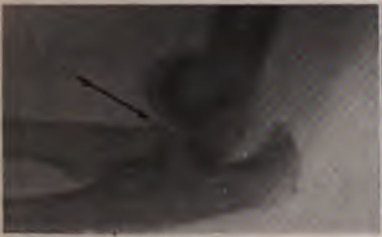


Fig. 241.

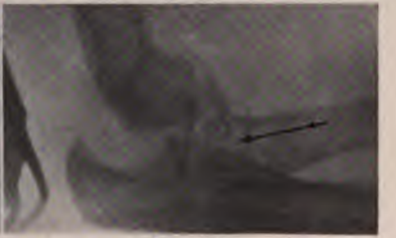


Fig. 242.

Fig. 241.—Backward luxation fracture of the tip of the coronoid process.
Fig. 242.—Backward luxation with comminuted fracture of coronoid process.

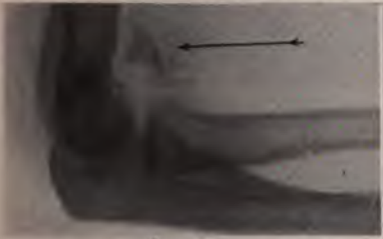


Fig. 243.

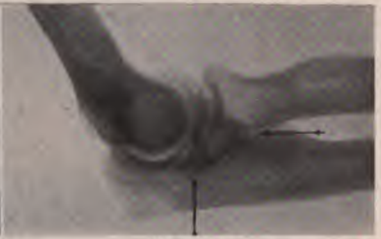


Fig. 244.

Fig. 243.—Large fragment of coronoid displaced upward by action of biceps. Fracture result of backward luxation of elbow.

Fig. 244.—Fracture of coronoid with only slight displacement. Result of backward luxation of elbow.

Treatment.—The treatment of dislocations of the elbow consists in returning the ulna and radius to their normal relations with the humerus, and immobilizing the elbow for a period sufficiently long to allow complete healing of the ligaments. The case should be attended as soon following the accident as possible. The longer the luxation exists the more difficult will be the diagnosis, the more painful the parts and the more pronounced the secondary traumatic reaction. Reduction of the dislocation is usually not difficult, and according to the most common method, consists (for backward luxations) in traction and counter-traction with hyper-extension of the joint followed by flexion. The arm is firmly grasped above the elbow with one hand while the other makes traction from the wrist; during this traction the forearm is somewhat hyper-extended to allow the coronoid to clear the trochlea, after which the forearm is flexed and reduction is complete. The ligaments are usually torn

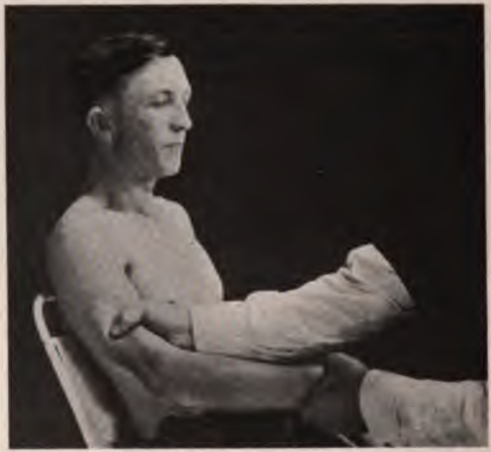


Fig. 245.—Method of reducing backward luxation of the elbow. Traction on the forearm at the wrist with counter-traction with the opposite hand on the arm. A greater degree of extension is often necessary to help the coronoid to clear the trochlea.

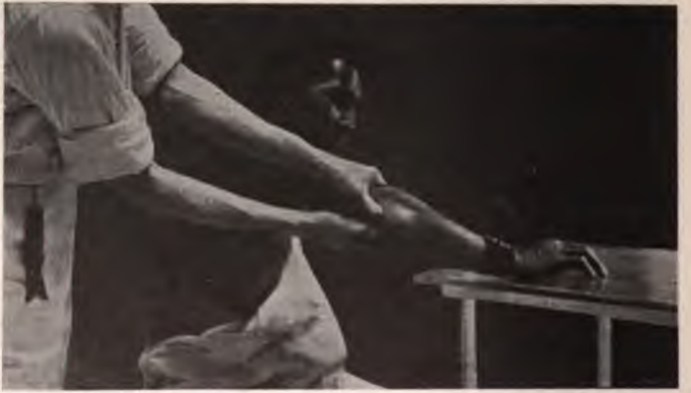


Fig. 246.—Another method of reducing backward luxations of the elbow. The lower part of the arm is grasped with both hands as shown in illustration while the thumbs force the olecranon downward into position. With the hand fixed on the table any desired degree of flexion at the elbow may be obtained during the manipulation.

to such an extent that they offer little resistance to reduction, but the muscles, especially in well developed persons, may as a result of spasm, render reduction extremely difficult. A method of reduction, particularly adapted to children, consists in forcing the olecranon into place with the thumbs while the fingers fix the arm above the elbow as shown in Fig. 246. By having the patient's hand resting on a table flexion and extension may be controlled by raising or lowering the elbow during the manipulation, thus helping the coronoid to clear the trochlea. Still another method is one in which the joint surfaces are separated and flexion of the elbow accomplished over the operator's knee. Reduction may also be accomplished by means of continuous traction with weights, but the first method described will be found as satisfactory as any in the average case of posterior luxation.

The muscles offer the chief obstacle to reduction and accordingly the use of an anesthetic will render difficult cases easy. The ligaments are already much torn and we should avoid manipulations which will subject them to further injury; this point should be kept well in mind when using an anesthetic, as the joint, under such conditions, is no longer protected by the action of the muscles. When the bones are displaced outward further than is caused by the internal lip of the trochlea (see Figs. 231 and 232), they should be converted into a simple backward dislocation before reduction is attempted. The less force used the better, and in a given case it is often preferable to try different methods with moderate force, before using any particular one with much force. There is probably no method, in backward dislocations of the elbow, which meets the indications as scientifically as does Kocher's in reduction of anterior luxations of the shoulder, yet the ones in use are effective and though not ideal are at least satisfactory.

In *reducing an outward luxation* it is of the greatest advantage to have an assistant fix the lower end of the humerus, thus affording the surgeon a solid basis on which to force the bones of the forearm into position. Before reduction is attempted the surgeon should know whether or not rotation is present, as well as lateral displacement. With the lower end of the arm fixed, traction is made on the wrist, while the opposite hand grasps the elbow and forces the upper ends of the radius and ulna downward and inward around the lower end of the humerus. If the bones of the forearm are displaced backward as well as outward it may be advisable to accomplish reduction as if the displacement were straight backward, with the addition of lateral pressure as the joint surfaces are being brought together. The most common obstruction to reduction is the lodgment of an epitrochlear fragment between the articular surfaces. If the elbow is hyper-extended this fragment can as a rule be gotten out from between the articular surfaces. Downward traction on the semiflexed forearm with a rocking motion will sometimes be effective in displacing the fragment.

Reduction of an inward dislocation is accomplished in a manner similar to correction of the outward displacement except that outward pressure is exerted during traction, instead of inward pressure. There is usually little difficulty in reducing this type of luxation.

In *forward luxations* with the usual fracture of the olecranon, reduction is accomplished by downward pressure on the upper part of the semiflexed forearm, thus forcing the head of the radius back onto the capitellum and the ulna back into alignment with the fragment of the olecranon. In the rare instances in which fracture of the olecranon does not complicate the luxation, reduction is accomplished by acutely flexing the forearm, and then forcing the tip of the olecranon past the trochlea by downward pressure. In the incomplete form of the dislocation, in which the olecranon lies on and not in front of the trochlea, this manipulation is fairly safe, but in the complete form there is grave danger of injury to the ulnar nerve. To lessen this danger the arm should be adducted until the olecranon has passed the trochlea. Complete forward luxation of the elbow is however extremely rare.

In *divergent luxations* of the elbow traction is to be made on the extended forearm and each bone reduced separately.

After reducing a dislocation of the elbow, regardless of the type, the joint should be carried through its normal range of motion and the parts carefully examined so that complications may not be overlooked.

Operative Treatment.—Operation is indicated when, after repeated trials under an anesthetic, the joint remains displaced and in cases in which complications such as irreducible fracture or injury to vessels or nerves exist. The joint may be approached by an external longitudinal or an internal longitudinal incision, according to the preference of the surgeon and the conditions present. The ulnar nerve lies internal to the elbow behind the epitrochlea, while the musculo-spiral descends behind the supinator longus as described in Operative Treatment of "Fractures of the Lower End of the Humerus" on page 148, and should be protected from injury during operation. It may occasionally be necessary to divide some of the ligaments to replace the bones. The external condyle may be broken off and displaced backward with the radius, and if the fragment cannot be accurately reduced by manipulation it is advisable to secure it with a nail or wire. The internal epicondyle may be separated, and when the fragment becomes wedged between the articular surfaces it may be necessary to operate to release it and effect reduction. Not infrequently internal fixation is indicated to maintain reduction of the fragment when fracture complicates the luxation, and the principles involved are the same as have already been described under the heading of Operative Treatment of "Fractures of the Lower End of the Humerus" on page 148. Fracture of the coronoid is not an uncommon complication and may, as a rule, be successfully treated with the elbow in the flexed position. When, however, the fragment is large and the upward displacement is so pronounced as to prevent approximation by flexion, it will be advisable to operate and suture the fragment in position. Suture of the ligament and surrounding soft tissues will, as a rule, suffice in holding the fragment in place.

Complicating fracture of the head of the radius does not call for operative intervention except in very rare cases.

When fracture of the olecranon exists it may be difficult to keep the fragments in apposition; open incision and internal fixation may be called for to secure proper reduction of the process. (See Operative Treatment of "Fracture of the Olecranon," page 191.)

The advisability of operating for the correction of old unreduced luxations depends almost entirely on the amount of function lost. If the patient is enjoying free use of the joint and the elbow is strong, it will be absurd to advise operation simply to correct the deformity. Operation for the correction of old displacements is performed according to the same principles, and the same precautions are to be observed, as already given in the open treatment of recent cases. A certain amount of fibrous tissue will usually be found within the sigmoid cavity and should be removed before the luxation is reduced.

After-Treatment.—The after-treatment consists in immobilizing the joint sufficiently long to allow proper healing of the ligaments.

In posterior luxations the anterior ligament is most extensively torn and the flexed position will be the one which will bring the torn ends nearest together; the same holds true when the coronoid has been fractured, therefore the best position will be found to be one just short of acute flexion. Complete flexion is a position which is quite uncomfortable and poorly adapted to the swelling of the elbow which is to follow, and for these reasons a position a few degrees short of complete flexion is advised. The arm and forearm should be bandaged in this position and the axilla protected to prevent skin coming in contact with skin, and some means of fixation applied as has already been described under the head of "Fractures of the Lower End of the Humerus," page 210. Passive motion of the joint should not be begun until the acute traumatic reaction has fully subsided, which will be at the end of a week or ten days. This will allow some time for the capsule to heal, but immobilization should not be too prolonged, as unnecessary stiffening of the elbow may result. Passive motion should not be delayed longer than two weeks and should at all times be gentle. When

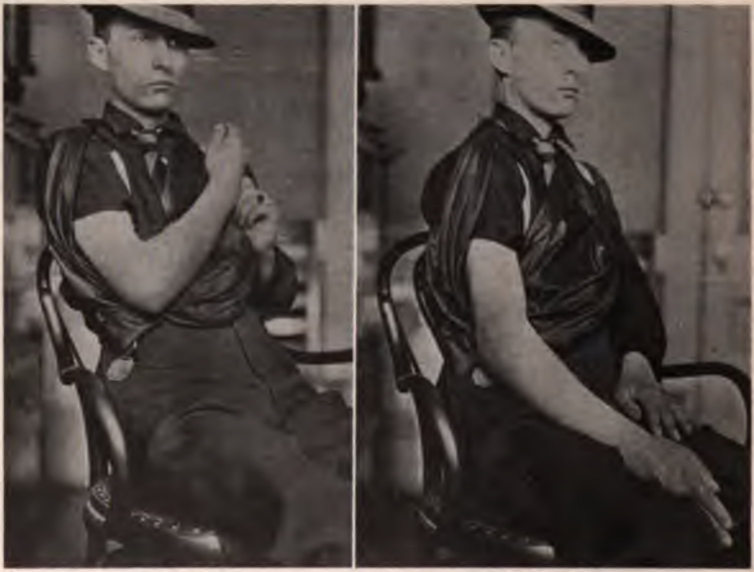


Fig. 247. Fig. 248.

Figs. 247 and 248.—These two figures show the range of motion fourteen days after a posterior luxation of the elbow. Note how the swelling has subsided as compared with the case seen twenty-four hours after the dislocation, as shown in Figs. 237 and 238.

once begun it should be practised every two to four days until complete or nearly complete motion is regained. The use of hot applications and massage daily will hasten recovery. The carrying of weights will materially increase extension during the latter part of the after-treatment. The elbow will show more or less stiffness when the dressings have been removed and will remain so for a short time but this is no occasion for anxiety as function will return with passive motion, massage, and use of the arm. Complete extension will be the last to return and may never be fully regained if the periosteum on the back of the humerus has been extensively stripped up and followed by a deposit of new bone under it in the region of the olecranon fossa. The fixation does not need to be as absolute as is maintained in fracture, but should be kept up for two to three weeks, and action requiring much strength should be avoided for another two to three weeks. The attitude to be particularly avoided is complete extension within a week of the injury, and this should be the last position in which muscular effort is permissible, after the patient is again using the arm.

Fixation in a position of supination will tend to relax the supinators and should be employed when complicating fracture of the external condyle or epicondyle exists. Flexion and pronation will relax the pull on the internal condyle and epitrochlea in the presence of fracture in this region.

The after-treatment of forward dislocations is much the same as has already been described. The presence of complications, such as nerve or vessel injury, may necessitate operation. The ulnar nerve may be stretched or torn and require suture.

The after-treatment of divergent dislocations is much the same as other dislocations about the elbow. The joint should be put at rest for a month to allow the ligaments to heal, but absolute fixation is not as desirable as it is in fracture. It is well to fix the elbow in a posterior right angle splint for the first ten days to two weeks, after which a sling may be used which supports the entire forearm. After the splint has been removed gentle passive motion may be employed at intervals of four or five days, but should be painless. Some restriction of motion may follow the injury and subsequent immobilization, but this is better than a condition of recurrent dislocation. Accordingly, in view of the extensive injury sustained by the ligaments and soft tissues, it is preferable to incline toward the safer course and not allow motion too soon. Extreme extension should be avoided during passive motion and the patient should be warned against strain in this position for some months following the accident.

Prognosis.—The prognosis in luxations of the elbow depends on the extent of laceration sustained by the ligaments and the presence of complications. The amount of damage to the ligaments is in direct proportion to the extent of displacement. In simple cases of posterior luxation we may look for complete restoration of function if the after-treatment is properly carried out. The last few degrees of extension may be permanently lost, but this does not disturb the usefulness of the joint and is negligible. Extensive injury to the soft tissues and complicating fracture will, of course, render the prognosis more doubtful.

Young persons make more rapid and complete recovery, while on the other hand those advanced in years (especially with rheumatic diathesis) are liable to be troubled with the joint for a long time. Fortunately the more common forms of dislocation are followed by useful and strong joints, if the ligaments are allowed time to heal. The dislocations that are accompanied by great laceration of the ligaments are most likely to be followed by weakness of the parts or recurrence of the displacement. Nerve injury accompanying the accident may be followed by paralysis and anesthesia, the same as nerve injury from other causes. Damage to nerves usually consists of simple stretching and is generally not severe. As a rule recovery takes place within a few months at most. Complete rupture of a nerve results in a permanent paralysis unless operated, and even then recovery may be extremely long and tedious. The ulnar nerve is most frequently involved, the musculo-spiral next, while the median nerve rarely suffers injury. Considering the frequency with which the elbow is dislocated injury to the nerves in this region is rare, and the ultimate prognosis, even in cases of complete severance, is good, if the divided ends are brought together and properly sutured soon after the accident.

CHAPTER XI.

DISLOCATIONS OF THE ULNA ALONE (ROTARY).

Surgical Anatomy.—The surgical anatomy of luxations of the upper end of the ulna alone, is similar to that already given in "Dislocations of the Elbow" on page 154. Dislocations of this type are quite rare, whereas luxations of the elbow (both bones) are by no means uncommon.

The upper end of the ulna may be displaced either backward or forward, describing the arc of a circle, of which the undisplaced radial head is the center. Both types are exceedingly rare, but of the two the posterior is the more common. In either form the interosseous membrane and oblique ligament are probably not torn, and the head of the radius remains in position on the capitellum. The injury is probably produced by trauma which twists the forearm at the same time adducting or abducting it.

Symptoms.—The *posterior variety* presents a characteristic clinical picture. The forearm is more or less extended and there is a pronounced "gunstock deformity." The olecranon is prominent and raised, though the displacement is usually not as pronounced as seen in posterior luxations of both bones. The tip of the coronoid may rest on the trochlea, or behind it, or the upper end of the bone may be still further displaced so that it rests behind the external condyle. The further the backward displacement of the upper end of the ulna, the more external will be the position occupied by the olecranon and the more pronounced will be the cubitus varus. The epitrochlea is prominent and more anteriorly situated than normal, with relation to the forearm. There is a compensatory outward rotation of the humerus to accommodate the altered position of the forearm. The internal lateral ligament may be ruptured or an equivalent avulsion of the epitrochlea may exist.

In *forward luxations* the ligamentary laceration, especially on the inner side of the elbow, is greater and the causative trauma is more severe. The forearm may lie anywhere between semiflexion and complete extension. There is abnormal lateral mobility in the direction of abduction. The top of the olecranon lies either on, or in front of, the trochlea and the position of the forearm is one of pronounced abduction. In other words, the carrying angle is greatly exaggerated.

A third form of luxation, so rare as to scarcely deserve description, is one of *inward luxation.* In this type the upper end of the ulna is displaced inward so that the sigmoid embraces the epitrochlea, while the radius remains in contact with the capitellum. The interosseous membrane, oblique and orbicular ligaments are of necessity ruptured and the upper part of the forearm is greatly broadened.

In all three forms of luxation of the ulna the head of the radius probably suffers a slight subluxation, but since it remains in contact with the capitellum it may for practical purposes be considered in normal position.

Treatment.—In *backward luxations* reduction is easily accomplished by extension and counter-extension in much the same way as has been described in the "Treatment" of "Dislocations of the Elbow." The adduction, which is due to the radius remaining in place, must be taken into account and requires a forced abduction of the elbow as extension and counter-extension are being made.

In *forward luxations* the ulna is returned to its normal position by inward rotation of the upper end of the forearm, accompanied by adduction of the forearm as the olecranon clears the trochlea.

The **After-Treatment, Operative Treatment** and **Prognosis** are similar to those already given under "Luxations of the Elbow," pages 170, 171 and 174.

CHAPTER XII.

DISLOCATIONS OF THE HEAD OF THE RADIUS.

Surgical Anatomy.—The head of the radius may be likened to a short cylinder. The upper end of the cylinder articulates with the capitellum and is slightly concave. The sides of the cylinder are in contact with the orbicular ligament and lesser sigmoid cavity while the lower end of the cylinder is continued into the neck of the radius. The lower end is slightly less in diameter than the upper end of the cylinder, and the orbicular ligament thus secures a hold on the upper extremity of the bone which tends to prevent downward displacement. The interosseous membrane and the oblique ligament, together with the orbicular ligament, bind the radius to the ulna though they allow free motion in pronation and supination. The external lateral ligament of the elbow is not attached to the radius but divides and blends with the orbicular ligament, passes in front of and behind the radial head, and is attached to the ulna anterior and posterior to the lesser sigmoid cavity. The head of the radius articulates with the lower end of the humerus and with the ulna at the lesser sigmoid cavity.

The radial head may be displaced: backward, outward, forward or downward. The exact mechanism of dislocations of the radius is not clear. The matters of importance are that the head is displaced and requires reduction. Fracture of the radial head or neck or of the upper end of the ulna may accompany the luxation.

Malgaigne's luxation (downward subluxation) has also been the subject of much discussion and there is little known concerning the mechanism of the injury. The consensus of opinion, however, is that there is a slight downward luxation of the radial head, and that there may be some infolding of the ligaments between the articular surfaces. This luxation is confined to children, usually under three or three and a half years of age, and is due to traction in the axis of the radius.

There is no hard and fast line to be drawn between outward and backward luxations of the radial head, one form merges into the other. The relation between these two types is much the same as that already noted between backward and outward luxations of the elbow. Any form of isolated luxation of the radial head is rare as compared with luxations of the elbow.

Symptoms.—In any type of luxation of the head of the radius there is pain in the region of the injury and loss of function immediately following the accident. The deformity will vary with the direction of the displacement.

In the backward or outward types the head is felt standing out in a position anywhere between posterior and external to its normal position, and may be identified by the characteristic cup-shaped extremity and by its rotation with the shaft during pronation and supination. The forearm is, as a rule, completely pronated and in a position just short of complete extension. Further examination shows that supination is checked by the altered mechanism of the joint, though strange to say this function seems to be regained in old unreduced luxations.

In forward luxations the elbow is partially flexed and the forearm may be either supinated or pronated, usually the latter. Pronation is, as a rule, complete, and passive supination blocked. Flexion beyond a right angle is never possible in recent cases; the head of the radius coming in contact with the anterior surface of the bone prevents flexion. Palpation of the forearm below the external condyle reveals the absence of the radial head from its normal position. The bend of the elbow is usually swollen and the displaced end of the bone may be palpated, though it is seldom as distinctly felt as is the case in backward and outward luxations. Old unreduced cases may show remarkable restoration of function as in the backward and outward types.

Downward luxation is productive of very mild symptoms. The child flinches at the time of the injury and may cry out. Disinclination to use the arm is at once noted, the forearm being held in a position of slight flexion and complete pronation. The child suffers little or no pain as long as the elbow is not brought into play, and accordingly the patient is very averse to having the member examined or in any way disturbed. If it were not for this disinclination to use of the member, the injury might frequently escape recognition. There is, as a rule, no deformity about the elbow to be appreciated by either inspection or palpation. In some

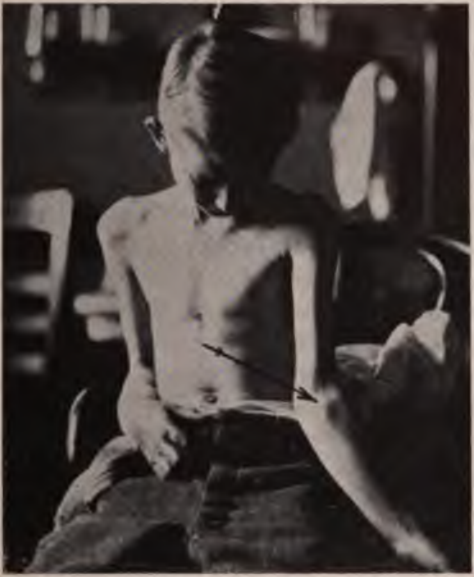


Fig. 249.—Forward luxation of the head of radius. Prominence indicated by arrow is caused by the displaced radial head. Note the exaggerated carrying angle which results from the head of the radius not bearing on the capitellum of the humerus. Flexion limited by the displaced radial head.

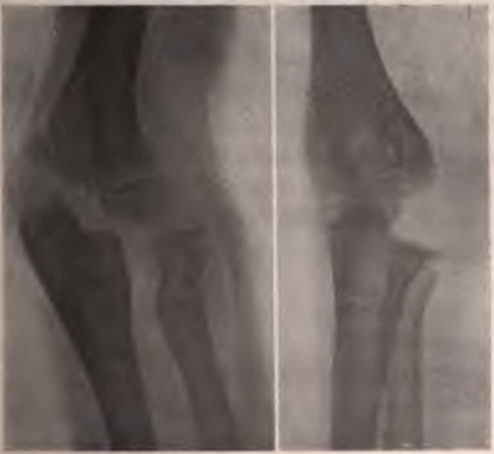


Fig. 250. Fig. 251.

Figs. 250 and 251.—X-rays of same case showing luxated radial head.

instances there may be a slight separation between the head of the radius and capitellum but this is usually so trivial as to be scarcely perceptible. Loss of function may persist for a long time if proper treatment is not instituted, though ultimate disability of the member seldom occurs.

Diagnosis.—The diagnosis of luxations of the radial head depends on the restriction of motion, the characteristic attitude and palpation of the head of the bone in its displaced position while the upper end of the ulna remains normally placed. The diagnosis of Malgaigne's luxation is based largely on the history of the case and the disinclination on the part of the child to use the member. The history is typical. The condition is the result of the pernicious habit of lifting a child by the hand; mothers are prone to do this in helping children on and off of street cars, and in hurrying them along the street. Following injury to the arm in this way the child fails to use the member and objects to having it disturbed.

The X-ray is of value chiefly in determining associated lesions, such as fracture of the radial head or neck or of the external condyle of the humerus, or a break in the ulna.

Treatment.—Reduction in the *backward and outward types* is usually easy, though the head may tend to slip out again as soon as the arm is released. Retentive dressings should be in readiness before returning the head to its normal position. Extension and counterextension, accompanied by direct pressure on the head in the direction of the capitellum, will, as a rule, effect reduction. The degree of flexion in which there is least tendency for the head to slip out of position should be determined in each case and the joint immobilized in this position. A pad maintained in place by straps of adhesive and exerting direct pressure on the upper end of the bone may be of service in preventing recurrence of deformity. The head of the bone may be fractured against the capitellum as it is driven out of place, and when this complication exists it may increase the tendency to relaxation.

In *forward luxations* similar principles are employed. Reduction is accomplished by extension, counterextension and direct backward pressure on the displaced head. When the head of the radius is felt to move backward the elbow is flexed and the manipulation is complete. To prevent recurrence of deformity the elbow should be immobilized in a position just short of acute flexion (see Fig. 210). When luxation of the radial head is complicated by fracture of the ulna, increased difficulty may be experienced in preventing reluxation. In addition to treating the dislocation we have the fragments of the ulna to maintain in apposition. Under these circumstances internal and external angular splints will be found more efficient than the position of acute flexion advised in the uncomplicated anterior dislocation. If the elbow is to be immobilized at a right angle the ordinary internal and external angular splints will be satisfactory. If, however, some other degree of flexion is desired plaster splints may be needed. If ordinary means are not efficient in preventing deformity in either the fracture or the luxation operation should be resorted to.

The reduction of Malgaigne's luxation is usually accomplished without difficulty. It consists in forcing the head of the radius upward against the capitellum, and is accomplished in the following manner. The surgeon grasps the lower part of the arm to fix the humerus while the opposite hand secures the forearm at about its middle; the forearm is then rotated (supinated and pronated) while upward pressure in the axis of the radius forces the head of the bone up against the capitellum. Reduction is usually accompanied by a soft click, after which all the functions of the joint are found to be normal and painless. Aften this maneuver is complete the elbow is tested by carrying the forearm through flexion, extension, supination and pronation. If the function is not completely restored and painless the manipulation should be repeated. It may be necessary to alternate extension with upward pressure. It will only be a few hours following reduction until the child is using the arm freely and without discomfort. The condition is not a serious one even if allowed to go unreduced, but proper treatment will relieve the child and obviate much anxiety. The displacement will not return unless the same forces which first produced the subluxation are again inflicted on the parts, and accordingly all that is necessary to prevent recurrence is to see that those having to do with the child are thoroughly informed and cautioned concerning the manner in which the injury was produced.

Operative Treatment.—The open method is indicated when other means fail to accomplish and maintain reduction for the correction of ancient luxations and occasionally in the treatment of complications. A longitudinal incision is made over the head of the radius, the bone exposed and reduction effected by direct manipulation. It may be possible to suture the torn orbicular ligament after the head has been replaced, though in some cases it may be difficult to recognize this structure. In any case it is proper to suture the structures surrounding the upper end of the bone in such a manner as to prevent redisplacement. When the radial head is much comminuted it is often better to remove the fragments, round up the end of the bone and suture the tissues about it. Rotation of the upper end of the bone, as evidenced by supination and pronation, is seldom lost following these operations if the axis of the radial shaft remains unchanged. Moreover these cases usually show a surprising stability of the joint when recovery is complete.

Complicating fracture of the upper end of the ulnar shaft is not an uncommon condition accompanying anterior luxation and may demand operation to maintain reduction in both fracture and dislocation. The dislocation is not particularly prone to recur but the fracture is sometimes difficult to hold in reduction because of the instability of the radio-humeral articulation. It is more often necessary to wire the fracture in the ulna than it is to operate on the luxation. If the ulna is approached through a posterior incision and the fragments secured by internal fixation it will often be possible to treat the luxation in the flexed position, and thus prevent displacement of the radial head.

If the upper end of the bone has been allowed to remain displaced the removal of longitudinal pressure commonly results in an over-growth of the bone with a corresponding increase in length. In operating on ancient luxations, therefore, it may be necessary to resect the head of the bone before the shaft can be brought back into alignment. Old anterior luxations come to operation more frequently than either the outward or posterior types because of the loss of acute flexion in forward dislocations. The excellent functional results following operation on old cases, even when the head is resected, are often surprising.

Malgaigne's subluxation never requires operation.

After-Treatment.—The elbow should be fixed in the position least favorable to recurrence for a period of at least twenty-five to thirty days. In anterior luxations there is usually less tendency to recurrence and accordingly the period of fixation need not be so long. Three to four weeks will, as a rule, be ample. When fracture complicates luxation union of the fragments is the chief consideration in the after-treatment and the retentive dressings should be removed only after one is satisfied that union is firm (usually four or five weeks). When fracture is present the case will require more careful supervision. The traumatic reaction is greater and the same precautions are to be observed as cited under fractures of the bones of the forearm. Malgaigne's luxation requires no after-treatment.

Prognosis.—In the uncomplicated luxation of the head of the radius, where reduction has been effected, restoration of function should be complete. If complications exist the prognosis varies with the nature of the associated injury.

CHAPTER XIII.

FRACTURES OF THE BONES OF THE FOREARM.

In considering fractures of the radius and ulna it will be found more satisfactory to describe them according to the level of the break rather than to take up each bone separately from end to end. It is well appreciated that various combinations of fractures may exist in the forearm regardless of the level; thus the lower end of the radius and the upper end of the ulna may be broken at the same time, or a fracture of the neck of the radius may be accompanied by a break in the lower end of either bone. It is manifestly impracticable to enter into the details of these various possible combinations of fracture, but if the student appreciates the nature of the breaks as described in the following pages he will be able to modify the treatment to meet the requirements of unusual combinations of fracture as they occur.

The order in which fractures of the bones of the forearm will be considered is as follows:

Fractures of the upper end of the ulna.
Fractures of the upper end of the radius.
Fractures of the shafts of the radius and ulna.
Fractures of the lower end of the ulna.
Fractures of the lower end of the radius.

CHAPTER XIV.

FRACTURES OF THE UPPER END OF THE ULNA.

Surgical Anatomy.—Much that has already been said concerning the anatomy of "Fractures of the Lower End of the Humerus" (page 120) and "Dislocations of the Elbow" (page 154) is equally important in fractures of the upper end of the ulna since the region is the same. Fractures of the upper extremity of this bone may be of the olecranon, the coronoid or just below the latter process in the upper thickened portion of the shaft. Occasionally the nature of the break or its position is atypical. Thé most important and at the same time the most common fracture occurring in the upper end of the ulna is of the olecranon process. This process is large, thick and curved, and projects upward behind the lower end of the humerus when the elbow is extended. Its upper surface is roughly quadrilateral and affords attachment to the tendon of the triceps. A portion of this tendon is continued through a heavy aponeurosis onto the posterior surface of the process, and thus the pull of the triceps may be exerted on the lower fragment in fractures of the olecranon, when the aponeurosis is not torn. The upper margin of the olecranon, anterior to the insertion of the triceps, affords attachment to the posterior bands of the lateral ligaments. These ligaments serve to keep the anterior surface of the process in contact with the trochlea when broken off from the remainder of the bone. The posterior surface of the olecranon is covered by a bursa and when this bursa is inflamed or enlarged as in "miner's elbow" the deformity may be marked. It does not resemble fracture but has been mistaken for it.

The interior of the olecranon is composed of a fine meshed cancellous tissue, while the surface consists of compact tissue, varying in thickness in different regions of the process. The compact bone is thickest in the region corresponding to the sigmoid cavity. That covering the posterior surface of the process is a little heavier than occurs in the adjoining regions. The cancellous tissue below the coronoid process is quite wide meshed and not as strong as that found in the olecranon. About half an inch below the coronoid the compact bone begins to grow thicker and rapidly increases in weight as the middle of the shaft is approached. The structure of the bone in the olecranon explains the inadvisability of using nails or screws when securing the fragments by internal fixation. (See Fig. 269, page 204.)

The upper epiphysis of the ulna consists of a thin layer or scale of bone at the top of the olecranon which first shows ossification in the tenth year, and joins the shaft during the sixteenth or seventeenth year. The fact that the triceps is attached not only to the upper end of the olecranon but to the posterior surface, accounts for the comparative rarity of avulsion and separation of this epiphysis. The line of the epiphyseal cartilage has been mistaken for fracture.

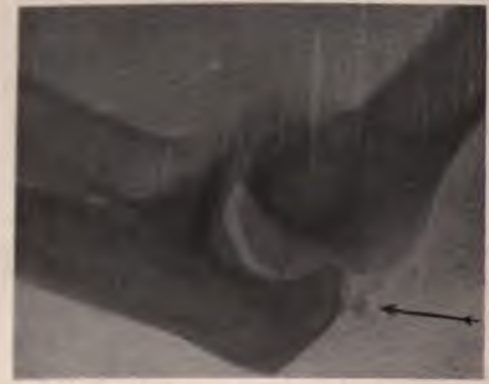


Fig. 252.—Avulsion of cortical layer of compact tissue in which triceps finds insertion.

As previously stated the powerful triceps is inserted into the olecranon process of the ulna, but its antagonist the biceps is attached to the bicipital tuberosity of the radius. Thus it will be noted that the heavy extensor and flexor muscles of the forearm are able to balance each other only because the two bones of the forearm are firmly bound together. Fracture of the olecranon, or fracture below the level of the sigmoid cavity with separation of the fragments, destroys the balance between the biceps and triceps. The brachialis anticus attached to the coronoid process is a flexor, and in fractures below the process this muscle tends to counteract the pull of the triceps, but its relative weakness results in the upper fragment being carried into extension if the aponeuroses have been torn sufficiently to allow deformity.

The mechanism of fracture of the olecranon has been the subject of considerable discussion; suffice it to say that most fractures of the olecranon are probably the result of a combination of direct violence and muscular action. Thus when a person falls heavily on the outstretched hand the triceps is firmly fixed in anticipation of the blow. If the force is great the hand is forced toward the body and a heavy strain is sustained by the process. Under these circumstances the elbow usually strikes the ground as flexion increases. Thus there is a combination of direct and indirect violence, and it is difficult to distinguish which of the two is the more important etiologic element. Cases are known in which the

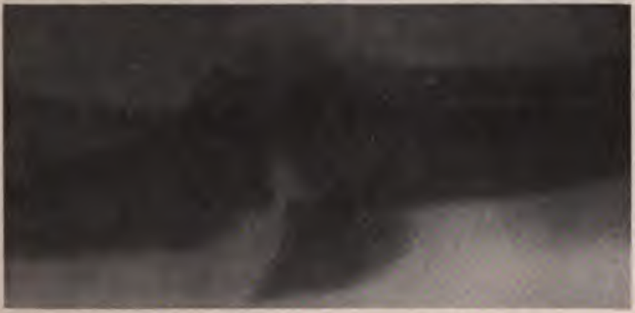


Fig. 253.—Fracture of olecranon. Elbow extended.

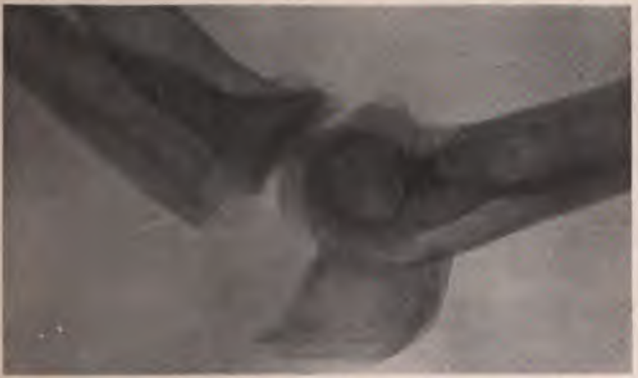


Fig. 254.—Same case. Elbow slightly flexed, showing increase of distance between fragments.

injury seems to have been produced entirely by muscular action, while in other instances direct violence alone has undoubtedly been responsible for the fracture. Fracture of the olecranon produced experimentally by direct violence has been of a different type than that commonly seen clinically. The amount of displacement of the upper fragment is usually greatest in cases resulting from muscular action though great separation is sometimes seen where the injury has been caused by a blow on the elbow. The displacement depends, to a great extent, on the tearing of the aponeurosis on the posterior surface of the process. The line of fracture is usually transverse and most often occurs at the bottom of the sigmoid fossa where the process is thinnest. The break usually enters the joint and when compound the elbow is exposed to infection. The deformity is usually characteristic; the upper fragment follows the curved surface of the trochlea so that the space left between the broken surfaces is the shape of a truncated wedge, with the narrow end of the wedge transversely situated against the trochlea while the base stands backward and downward.

Fracture of the coronoid is an extremely rare condition except as a complication of backward dislocation of the elbow (q. v.).

In fractures below the coronoid it is not uncommon to find the head of the radius luxated forward, which condition has been described under "Dislocations of the Head of the Radius."

Symptoms.—Immediately following the injury the patient finds that he is unable to actively extend the forearm, though motion may be accomplished passively or by the action of gravity. Motion is painful and the patient usually supports the forearm in a semiflexed position with the uninjured member. When separation is present the deformity is characteristic if seen early before the elbow is much swollen. The point of the elbow is gone; the posterior aspect of the joint has a rounded effect instead of its normal angularity, and in some cases the position of the displaced fragment may be determined by inspection alone. Swelling of the parts comes on rapidly in most cases, and after it is well established there is nothing characteristic in the outline to differentiate the condition from the swollen states seen following other injuries about the elbow. Palpation, however, readily clears up the diagnosis as shown in Fig. 256. In many cases there is separation of the fragments when the forearm is flexed but none with the elbow in extension, and accordingly the evidences of separation will vary with the degree of flexion at the elbow. Lateral mobility may be noted, especially abnormal abduction of the forearm. The distance between the fragments is variable, the greatest separation being seen in old cases with fibrous union, in which the bond has stretched with use.

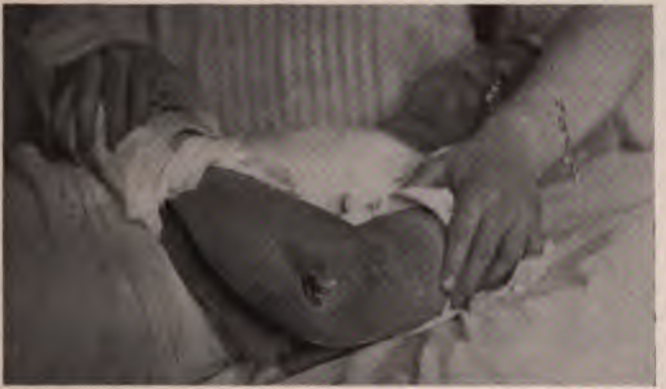


Fig. 255.—Fracture of the olecranon about one week following the accident. The characteristic deformity seen in recent cases is here obscured by the intense swelling. Note ecchymosis. Diagnosis cannot be made by inspection alone.

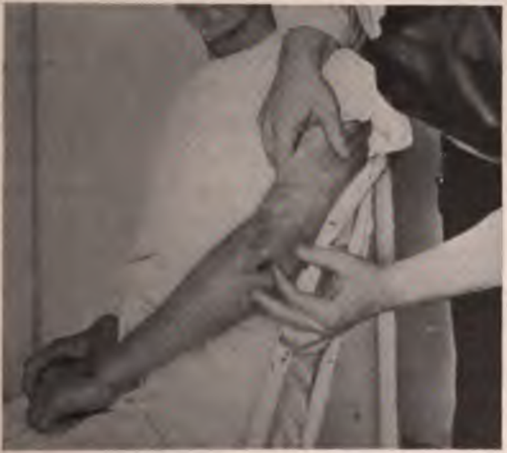


Fig. 256.—Same case. Diagnosis established by palpation. Thumb rests on top of olecranon. The index finger occupies the depression between the fragments. The middle finger rests on the upper end of the lower fragment. Note how the index finger sinks in between the fragments.

It is not uncommon to see fracture of the olecranon with little or no separation of the fragments, and under these circumstances some of the characteristic symptoms will be wanting. The power of active extension will be slightly if at all disturbed though the action will be painful. Lateral mobility of the process and crepitus are usually present though they are often not well marked when the fracture has been accompanied by only slight tearing of the aponeurosis. With separation of the fragments crepitus can only be elicited when the fragments are approximated and the broken surfaces rubbed together. Ecchymosis is almost invariably seen within twenty-four hours of the accident.

In compound cases the wound is usually situated on the posterior aspect of the elbow and it may be possible to see the line of fracture and the displaced fragment.

Fractures of the coronoid and fractures of the ulna just below this process have been considered under "Dislocations of the Elbow." Isolated fracture of the ulna just below the coronoid is an extremely rare accident and is usually the result of direct violence. It will be accompanied by abnormal mobility, crepitus, loss of function, etc.

Diagnosis.—If the case is seen early there will usually be little difficulty in recognizing fracture of the olecranon if the symptoms just described are sought. Fracture without displacement may escape recognition if the parts are not thoroughly and carefully examined. The posterior border of the ulna is subcutaneous throughout and by tracing it upward from below the position of the fracture and the displaced fragment can as a rule be felt. Even where there is no displacement it is often possible to detect some loss of alignment on the posterior border of the olecranon and by grasping the process laterally, motion and crepitus may be elicited. In establishing a diagnosis of fracture of the olecranon the elbow should be examined systematically as already described under "Fractures of the Lower End of the Humerus" (page 137) and in "Dislocations of the Elbow" (page 163).

The condition must be differentiated especially from fractures of the lower end of the humerus and backward luxation of the elbow.

Treatment.—The methods of treatment employed will depend entirely on the conditions present. Where there is no separation the right angle splint will meet the requirements of the case, in addition diagonal strips of zinc oxide adhesive should be so placed as to bind down the olecranon and relieve the upper fragment of the displacing action of the triceps. When displacement exists the time-honored straight splint is indicated. The elbow should not be treated in extreme extension because in the first place, the position becomes intolerable to the patient in a short time and secondly, the tip of the olecranon in this attitude is not sufficiently prominent to afford the proper purchase for the straps of adhesive used in binding the fragment in a position of reduction. A straight board may be used a little broader than the arm, and with sufficient padding at the elbow to allow a few degrees of flexion. The splint should be secured by three strips of adhesive plaster encircling the member; one at either extremity of the splint and the third just above the elbow. It should extend from a point just below the axillary fold to the wrist; there is little to be gained by extending the splint downward to include the hand, the patient being much more comfortable when some action at the wrist and fingers is allowed. The straight splint is very cumbersome at best and is not a desirable method of fixation when other means can be made to accomplish the purpose. A neat and satisfactory method of making a straight splint is to use quarter-inch iron wire; this is bent to fit the arm in a position short of complete extension and bandaged the same as the Cabot posterior wire splint employed in the treatment of fractures of the leg. A slight bend is made at the elbow to allow a little flexion of the forearm. When the fracture is compound it should be treated according to the principles laid down under "The Treatment of Compound Fractures and Luxations," on page 789.

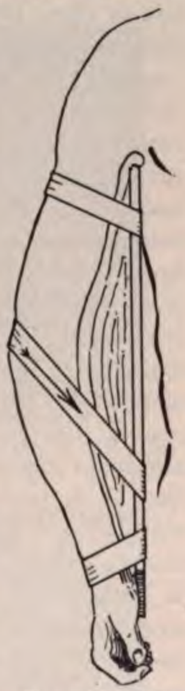


Fig. 257.—Illustrates the use of the straight splint in the non-operative treatment of fracture of the olecranon. Note the diagonal strap of adhesive which binds the upper fragment in position. Slight flexion of the elbow affords a better hold for this strip of adhesive.

Operative Treatment.—Of late years operation has, to a great extent, supplanted the ordinary methods, and there has been a great deal of discussion on the subject, pro and con. There is a large proportion of cases which make excellent functional recoveries without operation, and it is unwise to resort to the open method in all cases. When the fracture is not compound and there is no displacement of the fragments operative intervention can accomplish nothing, but on the other hand when there is displacement which cannot be perfectly corrected or when the fracture is compound there is no method that will be as successful as operation. Between these two types is a third class in which the best mode of procedure is not so evident. When the condition is not compound and there is only moderate separation, which can be fairly well corrected by other means, the question then arises: does the patient prefer to submit to an operation for the sake of a more rapid and perfect result, or would he rather endure a more protracted convalescence and assume the responsibility of an imperfect functional result which may go with fibrous union? In these borderland cases the situation should be laid before the patient and he should be the one to assume the responsibility if operation is rejected. Fibrous union, when the fragments are close and the mass of fibrous tissue heavy, is usually accompanied by excellent results, and cases in which these conditions obtain are a strong argument against operation. It should be remembered, however, that it is impossible to foretell just how strong fibrous union will be in a given case. The age, condition and occupation of the patient are factors which must be taken into consideration in advising the proper method of procedure. Limitation of full extension is directly proportionate to the separation of the fragments. If the broken olecranon is displaced upward it becomes seated in the olecranon fossa before the elbow is fully extended, and thus motion is limited. Full extension, therefore, cannot be expected unless the fragments are in accurate apposition. It might be stated as a rule that young or middle aged persons, especially of the working class, should be operated when the fragments cannot be approximated by ordinary methods. By the open method convalescence is shortened and the function of the joint is more completely restored.

The process is exposed through a longitudinal incision external to the posterior surface of the olecranon. The scar in this position is not exposed to pressure when the patient rests the elbow on a table or other convenient object. After the fragments are exposed two transverse holes are drilled one above and the other below the plane of the fracture. All loose tissues are then cleared away between the two fractured surfaces and the upper fragment brought down and accurately fitted into the serrations of the lower one. Suture material is then passed through the holes and the fragments solidly secured in position Instead of this method a heavy mattress suture may be placed, as shown in Fig. 259.

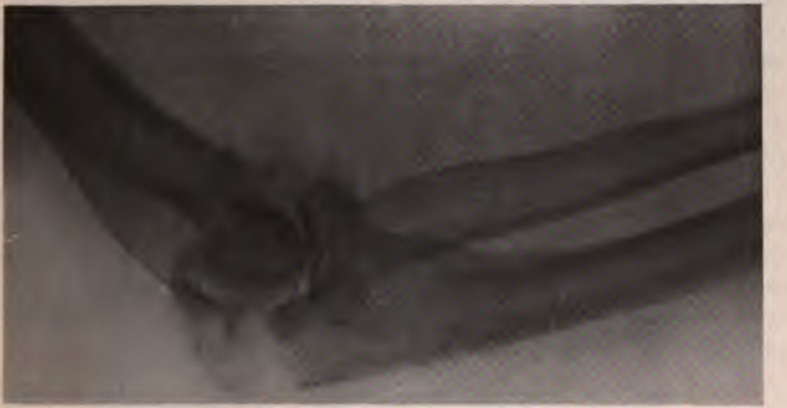


Fig. 258.—Fracture of olecranon showing separation of fragments in spite of dressings tending to correct the deformity.

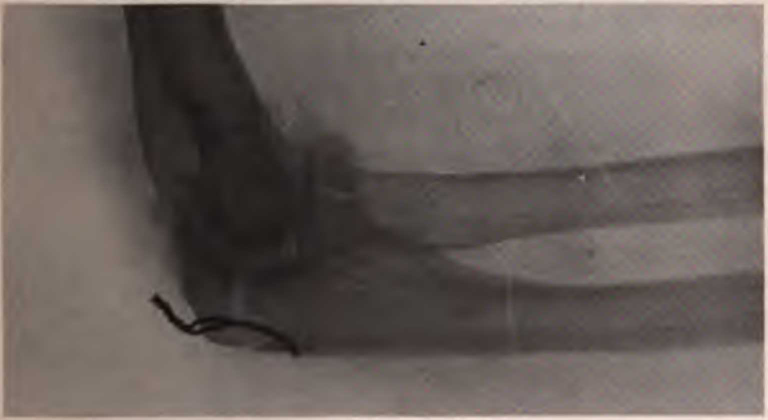


Fig. 259.—Same case showing accurate reduction following operation in which mattress suture of silver wire was used to maintain reduction.

There has been considerable discussion concerning the best type of suture, and of late absorbable materials such as chromic catgut and kangaroo tendon have been frequently employed. The author much prefers wire to absorbable material, since the latter is more or less likely to soften and stretch before the callus is firm enough to withstand the unavoidable tension of the triceps, and when it does there will be at least some slight separation of the fragments. Silver wire has no stretch in it and will hold the fragments in position as long as may be necessary, and in addition will permit of early and repeated passive motion with greater safety. (See "Operative Treatment of Fractures," page 758.) In compound cases the wound should be irrigated with a few gallons of physiologic sterile salt solution, and the edges of the wound trimmed of devitalized tissue as described in "The Treatment of Compound Fractures and Luxations," on page 789. Internal fixation of the fragments should not be performed at the initial operation in compound cases though it may be possible to retain the fragments in position by suturing the fascia covering the posterior surface of the process, in closing the wound. A secondary operation may be done after the wound (rendering the condition compound), has healed and the danger of infection has passed.

Following a firm internal fixation of the fragments the upper extremity may be immobilized with an internal right angle splint.

Old cases of fracture of the olecranon sometimes require operation because of separation of the fragments and loss of function. The difficulty is purely mechanical and calls for mechanical correction. The joint is approached through a longitudinal incision as just described; the fibrous tissue is excised and the upper fragment brought down into apposition with the lower. The ends of the fragments must be freshened before being sutured together, but as little bony tissue should be removed as possible. In cases of long standing it may be necessary to lengthen the tendon of the triceps so that the elbow may be fully flexed after the fragments have been sutured together.

In rare instances fracture of the coronoid may require operation if the fragment is large and much displaced, and if immobilization of the elbow in the flexed position does not effect reduction. It will usually be possible to retain the fragment by suture of the soft parts since there is little displacing action if the elbow is subsequently fixed and treated in the flexed position. In making the incision to expose this process the greatest care should be exercised to avoid injury to the brachial artery and median nerve as they pass across the bend of the elbow.

Fracture of the upper end of the ulna below the coronoid is especially rare and seldom requires operation except when accompanied by anterior dislocation of the elbow. The treatment of this condition has been considered under "Dislocations of the Elbow," page 170.

After-Treatment.—If non-operative methods have been followed and the straight splint used the arm should be inspected daily for the first two weeks to see that there is no undue constriction of the parts and that the straps binding the olecranon down are accomplishing the purpose. The same precautions are to be observed if the right angle splint is employed. If the soft tissues have suffered much injury it is usually advisable to delay reduction of the fracture until the traumatic reaction has subsided. During this time it is best to treat the patient in bed with the arm immobilized on an internal right angle splint. The intermittent use of the ice cap will aid materially in controlling the reaction. The swelling will, as a rule, have subsided sufficiently at the end of a week or ten days to permit of reduction and immobilization, or operation if thought best. Massage is of great service after the swelling has passed off but is capable of doing harm during the active inflammatory reaction. Passive motion should be instituted at the end of two weeks but should be guarded, gentle and painless at first, and the arm should be carried through only a few degrees of flexion. At the end of three weeks much freer motion is permissible in manipulating the elbow. The greatest care, however, should be exercised

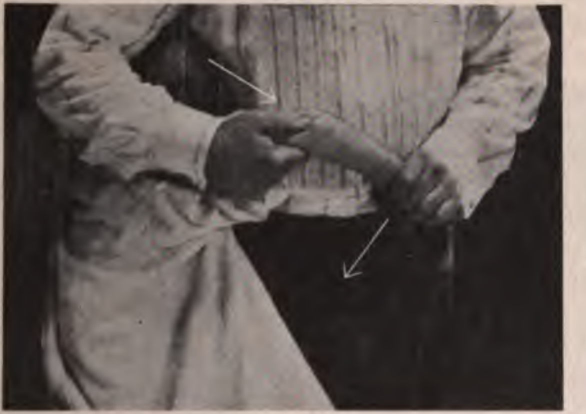


Fig. 260.—Illustrates method of employing passive motion in the after-treatment of fractures of the olecranon. The thumb forces the olecranon to follow the shaft of the ulna as the elbow is being flexed.

at all times not to cause separation of the fragments during passive motion, especially if they have not been wired. In moving the joint the thumb should be placed above the process as shown in Fig. 260 and downward pressure exerted on the end of the process to force the fragment to follow the movements of the shaft during flexion of the elbow. Early passive motion is essential to the prevention of adhesions within the joint, yet if not properly guarded it may do more harm than good. Union of the fragments usually takes place at the end of three or four weeks, but the callus is not strong enough to withstand much strain at this time. At the end of four or five weeks immobilization may be discontinued. At the end of two and a half to three months recovery is complete though the patient should be cautioned not to use the arm in any work requiring violent extension, within six months from the time of the injury.

Prognosis.—The prognosis depends on the severity of the injury and the efficiency of the treatment. In the uncomplicated case, with little or no separation of the fragments, perfect restoration of function should follow non-operative treatment. Recovery with fibrous union may or may not be accompanied by a useful elbow. If the fibrous tissue is short and thick, function will, as a rule, be good. If it is thin and stretches with use the power of the triceps will be lessened or lost and extension incomplete. Severe traumatic reaction and prolonged immobilization of the elbow render the prognosis worse, since they are productive of joint adhesions. Approximation of the fragments by internal fixation and early passive motion are usually followed by complete restoration of function. It is of course possible to have perfect function with fibrous union, while on the other hand loss of function may be pronounced even when the anatomical result is perfect. The largest percentage of perfect results, however, will be found in the cases showing the most perfect reduction, other things being equal. In compound cases the prognosis depends largely on whether or not the joint becomes infected. (See "Treatment of Compound Fractures and Luxations," page 789.)

CHAPTER XV.

FRACTURES OF THE UPPER END OF THE RADIUS.

Surgical Anatomy.—The sections on "Surgical Anatomy" under the headings of "Fractures of the Lower End of the Humerus," "Dislocations of the Elbow" and "Dislocations of the Head of the Radius" apply in a large measure in fractures of the upper end of the radius. The head of the bone is surrounded by the orbicular ligament, except where the latter comes in contact with the lesser sigmoid cavity of the ulna. The supinator brevis is attached to the shaft and extends upward onto and almost completely surrounds the neck of the bone. The biceps is attached to the posterior half of the tuberosity and acts as a supinator of the forearm as well as producing flexion. A bursa is interposed between the tendon of this muscle and the anterior half of the tuberosity. The interior of the head of the radius is composed of a fine meshed cancellous tissue which is covered by a layer of compact bone. The surface compact tissue is heaviest on the top of the head. The circumference of the head, coming in contact with the orbicular

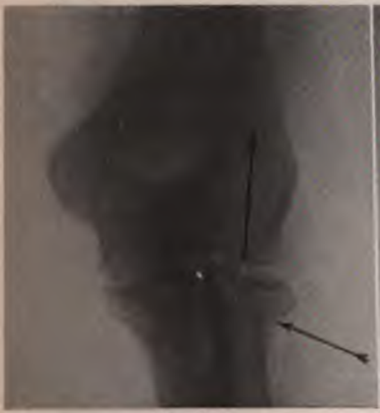


Fig. 261.

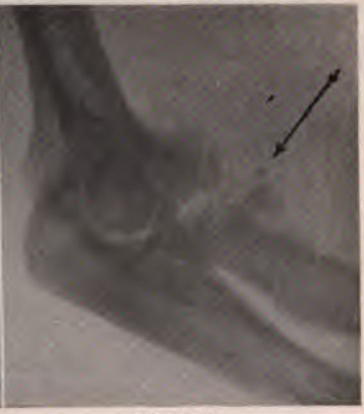


Fig. 262.

Fig. 261.—Fracture of head and neck of radius.
Fig. 262.—Comminuted fracture of head of radius.

ligament, is covered by only a very thin layer of compact bone. That found on the surface of the neck is a little heavier. The tuberosity is not a heavy, solid prominence of compact tissue but is composed only of a thick crust of compact bone, the interior being made up of a wide meshed cancellous tissue.

The upper epiphysis of the radius consists of a scale of bone corresponding to the superior articular surface. When viewed laterally under the X-ray it appears as a line, throwing much the same shadow as would a coin seen on edge. This epiphysis begins to ossify in the fifth year, and joins the shaft during the seventeenth or eighteenth year.

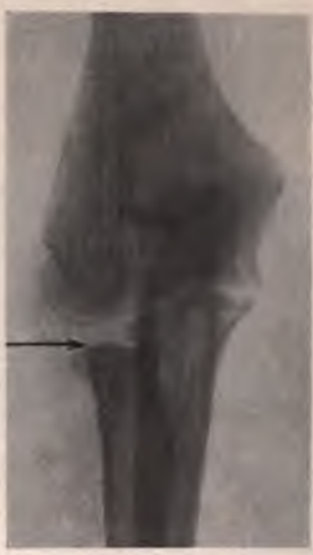


Fig. 263.—Fracture of head and neck of radius.

Fracture of the upper end of the radius is rare. The head may be broken as a complication of luxations, by violence transmitted in the long axis of the shaft (such as sustained in falls on the hand) and by direct trauma. The fracture may consist of a small fragment detached from the articular surface or the entire head may be extensively comminuted. Impaction of the neck into the head is not an uncommon type of injury. When this occurs impaction is usually greater on one side of the bone than on the other, so the head is no longer "true" when the shaft is rotated.

Fractures of the neck are usually transverse or nearly so. A vertical fracture may exist passing through both head and neck.

Fractures of the upper end of the radius are, as a rule, accompanied by only slight deformity, if any, and almost invariably exist as complications of dislocations of the elbow or radial head alone, or of fracture of the lower end of the humerus or of the ulna. As an isolated injury they are unusual though by no means as rare as supposed prior to the advent of the X-ray.

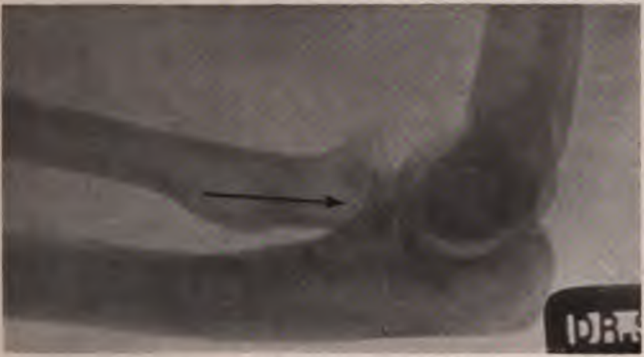


Fig. 264.—Fracture of head of radius.

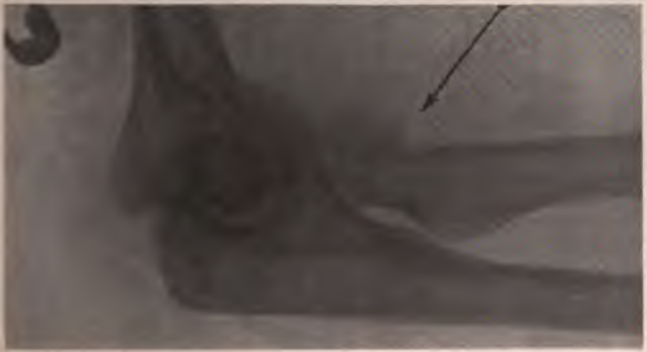


Fig. 265.—Fracture of head of radius. Neck of bone has been impacted into head. Head "off center."

Symptoms.—Fracture of the head of the radius alone is often productive of very few symptoms, and if not thoroughly examined the condition may be overlooked and treated as a sprain. Local pain and swelling are present over the head of the bone. The swelling may extend halfway down the outer aspect of the forearm and local spasm of the muscles in this region is almost invariably present. Supination and pronation are usually possible but this rotary action of the forearm may be restricted through spasm and pain, or by the head of the bone being "off center." If a fragment becomes displaced into the joint it may block either flexion or extension of the elbow.

It may be possible to detect crepitus by direct manipulation and in some cases a fragment may be felt and moved. Crepitus is most commonly elicited by supinating and pronating the forearm while the fingers of the opposite hand palpate the head. The head of the bone may or may not rotate with the shaft during this manipulation, depending on whether or not the fractured surfaces are firmly engaged. It is impossible to detect crepitus in impacted cases. Failure of the head to rotate with the shaft is conclusive when present, but it is not at all uncommon to find the head rotating with the shaft in the presence of fracture of the head or neck. When the fractured surfaces are not engaged the biceps may pull the upper end of the lower fragment forward and the resulting change in the axis of the radial side of the forearm may be apparent. This forward displacement by the biceps usually hinders flexion until the deformity is corrected.

Diagnosis.—The diagnosis of fracture of the upper end of the radius may be very easy or quite difficult, depending on the symptoms. If the parts are carefully examined it will usually be possible to determine the nature of the injury by the symptoms just described, but in some cases (especially well muscled persons and instances in which the swelling is pronounced) a Röntgenogram may be necessary to arrive at a diagnosis. Behind the external condyle of the humerus and head of the radius, and internal to the extensor tendons arising from the epicondyle, is a depression or dimple which affords ready access in palpating these bony parts. A slight transverse depression between the capitellum and radial head may be felt and the radius should be distinguished from the humerus. The surgeon should not make the mistake of palpating the external condyle to determine rotation of the radial head. Such a mistake would not seem probable yet the author has seen it made more than once. The X-ray should be used if there is the least doubt as to the nature of the condition.

Treatment.—The management of these cases depends on the nature of the fracture, the displacement of the fragments and the association of other lesions. When the fracture is confined to the head, the orbicular ligament, if not ruptured, will usually prevent displacement of the main fragments, though a portion of the head may escape into the joint and require removal. As a rule, however, fracture of the upper end of the radius calls for little aside from immobilization of the forearm, which is well accomplished by an internal right angle splint. If the head is badly comminuted it may be advisable to remove the fragments, round up the end of the shaft and secure it in place by suturing the orbicular ligament and other adjacent fibrous tissue over it. When obstruction to flexion or extension is caused by a detached fragment of the head it should be removed. When the fracture is below the head, and the shaft is displaced forward by the action of the biceps, the splint should be so padded that pressure will be made in a backward direction on the upper end of the lower fragment. The use of pads and the acutely flexed position should never be employed at the same time. The use of padding in the bend of the elbow with the forearm in acute flexion, may give rise to

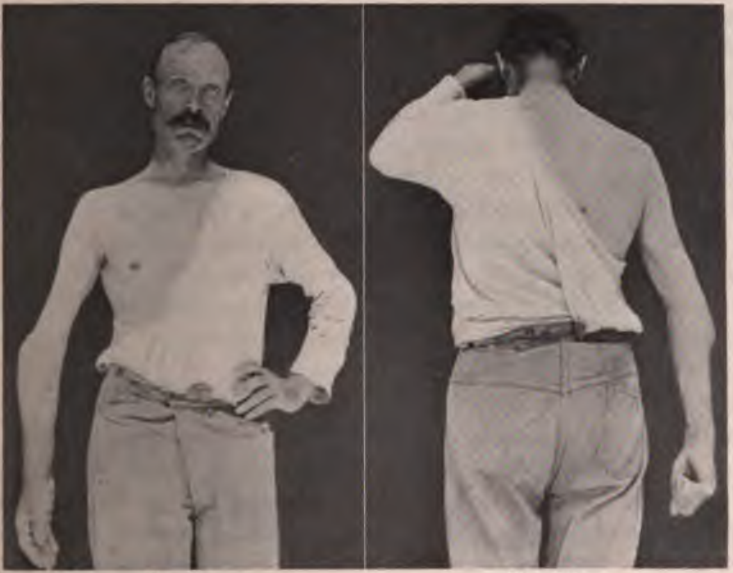


Fig. 266. Fig. 267.

Figs. 266 and 267.—Loss of carrying angle and gun-stock deformity the result of fracture of both bones *below* the elbow. Palpation in this case shows the humeral condyles and olecranon to be in normal relation. Loss of carrying angle and gun-stock deformity are usually the result of fracture of the lower end of the humerus.

serious disturbances of the circulation and in the function of the median nerve. When the fracture is below the orbicular ligament acute flexion will sometimes afford better reduction than the use of direct pressure and the right angle splint.

Operative Treatment.—Operation may be indicated for the removal of a loose fragment in the joint or to apply internal fixation to a fracture of the neck when other means fail to maintain reduction. The open method, however, is seldom called for in recent cases. When a loose fragment requires removal the incision will be made according to the position of the fragment. For other conditions of the upper end of the radius, requiring operation the posterior longitudinal incision will be found as satisfactory as any. The posterior aspect of the external condyle is a landmark from which the incision is begun and carried directly downward from two to three inches; after the skin incision is made the muscles are separated and the upper end of the radius exposed. In the presence of much comminution the head is to be excised, the end of the shaft rounded up and sutured in place. If the fracture is somewhat below the head it may be possible to so place a loop of wire that the lower fragment will be bound to the upper, thus preventing the forward displacement due to the pull of the biceps. The action of the biceps may be somewhat further relaxed by putting the arm up in greater flexion than the right angle. There is little that can be done with fracture of the head aside from excision, but unless the comminution is great it is best to wait and determine how much restriction of motion will be present when recovery is complete. If the loss of function is then pronounced a secondary operation may be performed and the head removed. It is surprising what good results often follow complete excision of the head. Fractures above the lower border of the orbicular ligament seldom unite, regardless of the treatment employed, so there is little use in attempting anything in the way of operative procedure aside from excision in fractures confined to the head.

After-Treatment.—The after-treatment of fractures of the upper end of the radius, like other fractures about the elbow, requires close attention to avoid constriction when swelling sets in, and as the arm decreases in size during the subsidence of this swelling the dressings should be tightened daily to secure proper support and immobilization. In children union will be present at the end of two and a half weeks, but is not firm enough at this time to permit of removal of all dressings; the member should be protected and supported for another ten to fifteen days before all splints are removed, especially if the child is active and not easily controlled. In adults the parts should be immobilized for a period varying from three to five weeks according to the age of the patient. If the fracture is confined to the head union cannot be expected, regardless of the period of immobilization, and the most important element in the after-treatment is then the early institution of passive motion to preserve the rotary action of the forearm. Passive supination and pronation should be begun as early as the end of the first week or ten days unless the traumatic reaction persists. When the fracture is of the neck passive motion should be delayed until union is firm enough to withstand manipulation.

Prognosis.—The outlook depends on the nature of the fracture and the treatment followed. In extensive comminution of the head there is likely to be pronounced loss of supination and pronation of the forearm although the rotary action of the forearm is usually restored with operation and excision. Perfect function should follow fracture of the neck if the fragments unite in approximation; if there is deformity following recovery the rotary action of the forearm may be seriously impaired.

CHAPTER XVI.

FRACTURES OF THE RADIAL AND ULNAR SHAFTS.

Surgical Anatomy.—The shafts of the bones of the forearm may be broken together, or either bone may be broken separately. It is more common to see both bones broken than to find a fracture of either bone as an isolated injury. Fracture of the radius alone is often the result of indirect violence; the lower end of the radius supports the carpus and violence sustained by the hand is transmitted to this bone rather than the ulna. Fracture of the shaft of the ulna is usually the result of direct violence; the posterior border is subcutaneous throughout and is particularly exposed to injury in falls on the back of the forearm and in warding blows

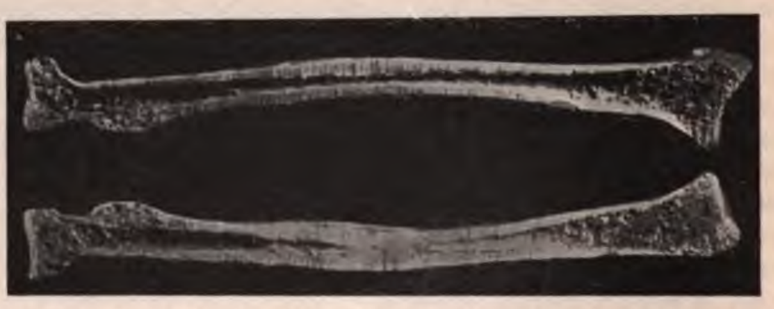


Fig. 268.—Section of radius showing disposition of compact and cancellous tissue.

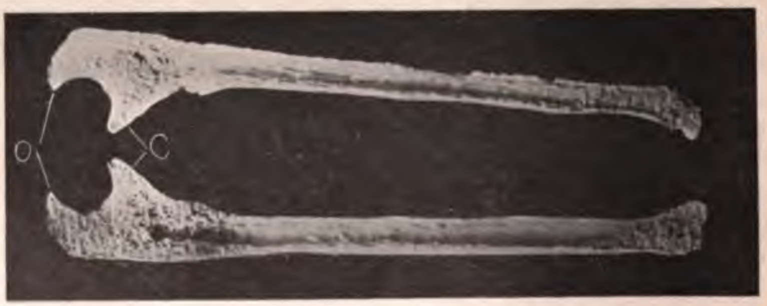


Fig. 269.—Section of ulna showing disposition of compact and cancellous tissue. *O.*, Olecranon; *C.*, Coronoid.

from the head. When both bones are broken the cause may be either direct or indirect violence. Fracture of the bones of the forearm is a particularly common accident in childhood. When the shaft of either bone is broken alone the deformity is, as a rule, not pronounced since the opposite shaft acts as a splint in preventing displacement.

The various deformities accompanying fractures of the radial and ulnar shafts depend on the nature and direction of the causative trauma and the different muscles attached to the bones. In speaking of the deformities due to muscular action in different regions of the forearm it will be understood that they obtain only when the serrated fractured surfaces are not so engaged as to prevent displacement. Fracture of the radial shaft, below the tuberosity and above the insertion of the pronator radii teres, is likely to be accompanied by supination of the upper fragment and pronation of the lower. The biceps and supinator brevis produce supination of the upper fragment, and the first named muscle will also tend to displace the lower end forward. The lower fragment will occupy a position of pronation due to the action of the pronator radii teres and the pronator quadratus, and the upper end of the lower fragment will usually be displaced toward the ulnar shaft through the action of these two muscles. When the fracture is below the insertion of the pronator radii teres both fractured ends will be displaced toward the radius by the pull of these two pronators. In fractures of the shaft of the ulna the upper end of the lower fragment may be displaced toward the radius by the action of the pronator quadratus; the nearer the fracture is situated to the upper border of this muscle the more pronounced the action.

The relation of the bones during supination and pronation is of importance in treating fractures of the forearm. In supination the interosseous membrane is taut and the two bones in the same plane. As the forearm is carried into pronation the lower end of the radius describes an arc about the lower end of the ulna, and when pronation is complete the radial shaft crosses the shaft of the ulna obliquely. In complete pronation the shafts of the two bones are nearer than in any other position. The obliquity of the fibres of the interosseous membrane is such that with upward longitudinal stress on the radius a portion of the strain is imparted to the ulna. The oblique ligament is composed of fibres passing in the opposite direction and tends to prevent the radius being pulled away from the humerus. The shafts of both bones are composed of heavy tubes of compact tissue, and the fractures seen in this region are those common to the shafts of other long bones. They may be transverse, oblique, spiral, comminuted, multiple, green-stick, subperiosteal, etc. Divergence of either the upper or lower pair of fragments occurs only with rupture of the interosseous membrane and is rare. In unusual cases the ends of all four fragments may be close together and embraced by one callus. In other instances angular deformity of the fragments of one bone toward the opposite shaft may be accompanied by a large callus which interferes with the rotary action of the forearm. When both bones are fractured the break in the ulna is usually at a slightly higher level. In rare instances the fractures may be situated at opposite ends of the shafts. Muscular action is known to have produced fracture of the bones of the forearm, but is extremely rare.

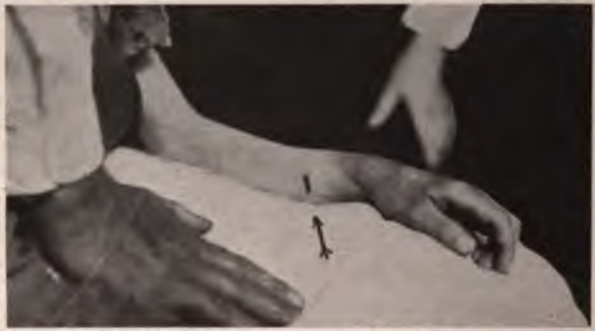


Fig. 270.—Fracture of both bones of the forearm the result of direct violence. Hand displaced dorsally and slightly to the radial side. Fracture of ulna transverse and deformity purely angular. Fracture of radius is slightly oblique so that there is an element of overriding as well as angularity in the displacement of this bone. The slight overriding of the radial fragments causes the hand to be displaced a little to the radial side as well as backward. Arrow points to wound produced by lower end of upper fragment of radius penetrating the skin. Angular deformity corrected at once. Radius could not be perfectly reduced and persisted in slipping out of place. Operation about one week following injury; radius secured in reduction by circular wire, which is bad practice in compound cases before the wound has healed. (See "Operative Treatment of Compound Fractures and Luxations.") Ultimate recovery perfect.

Symptoms.—The symptoms accompanying fractures of the bones of the forearm vary with the region of the fractures, the age of the patient, and whether or not both bones are broken. *In fractures of the radial shaft* the deformity is usually not pronounced and may be quite difficult to recognize. If one or both fragments are displaced toward the ulna the radial side of the forearm may

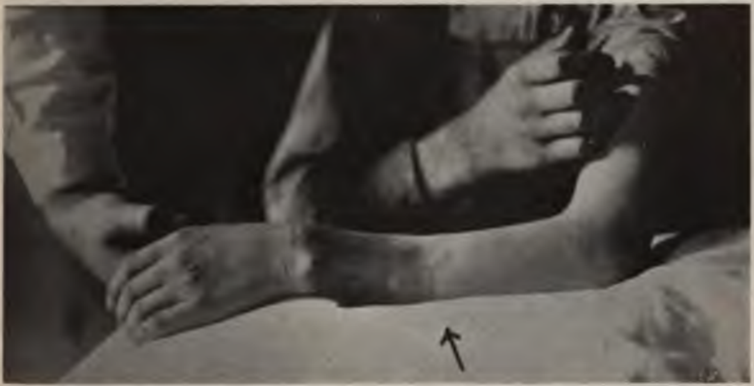


Fig. 271.—Another view of same case showing dorsal surface of forearm. Note the transverse groove indicated by the arrow. This groove indicates to some extent the relative levels of the two fractures. These photographs were taken immediately following the accident and just prior to reduction.

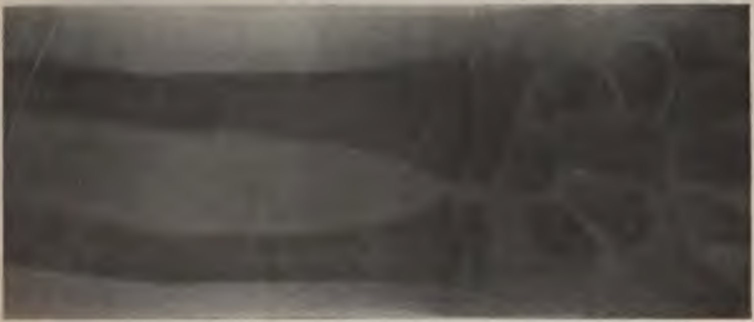


Fig. 272.—Antero-posterior view of fracture of radius and ulna after reduction has been attempted.

Fig. 273.—Lateral view of same case showing deformity in radial fracture. The fracture in the radius is slightly oblique and persists in slipping out of position after reduction. On this account operation was performed and reduction secured by a circular wire.

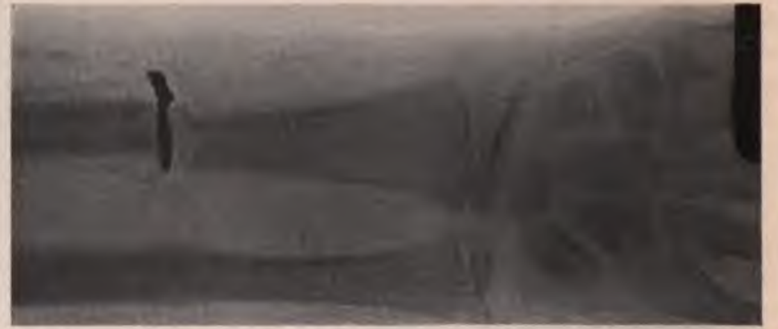


Fig. 274.—Antero-posterior view of same case some weeks after operation. Circular wire was used and infection followed. The case was compound from the first. The placing of foreign materials, especially of the non-absorbable type, is to be condemned in operating on compound fractures. Some absorption of bone has taken place under the wire, and as a result slight recurrence of deformity. Wire removed—perfect recovery followed.

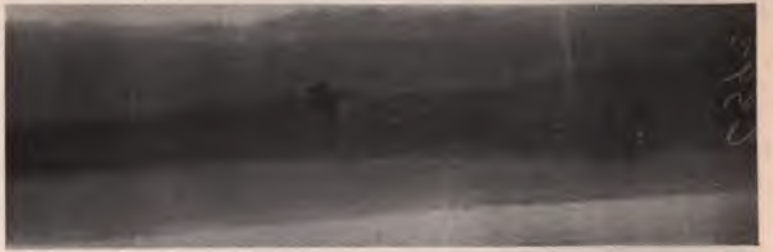


Fig. 275.—Lateral view of same case.

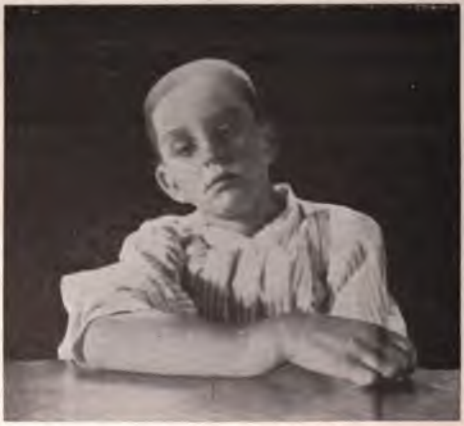


Fig. 276.—Fracture of both bones of the forearm with the usual backward displacement of the hand. Photograph about one and a half hours following the accident. Angular deformity pronounced but there is no overriding of the fragments.

show an abnormal concavity as illustrated in Fig. 287. In any case there will be pain in the region of the fracture, tenderness on pressure and manipulation, swelling and more or less complete loss of function. If the fracture is in the lower third of the radius and the upper end of the lower fragment displaced toward the ulna, the radial styloid will be correspondingly raised and the lower articular surface changed in position. Overriding of the fragments and shortening, however, will be absent unless the head of the ulna is luxated or the ulnar shaft fractured. During supination and pronation of the forearm the radial head will, in most

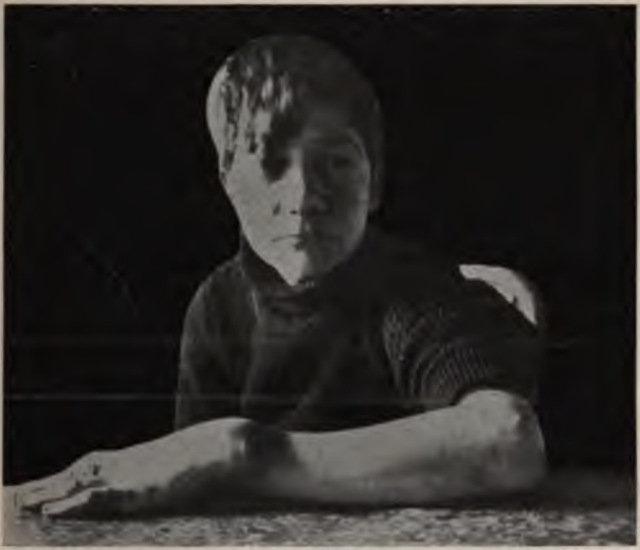


Fig. 277.

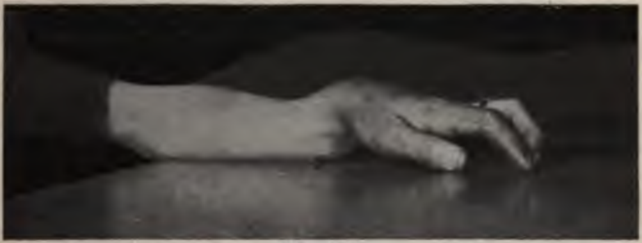


Fig. 278.

Figs. 277 and 278.—Fracture of both bones of the forearm with the usual deformity. Fractures at about same level. Pictures taken a few minutes following the accident.

cases, fail to follow the rotation of the shaft. Crepitus can, as a rule, be elicited if the fragments are grasped above and below the seat of the fracture and manipulated. If the forearm be placed in supination and firmly held in this position, while lateral pressure is exerted on the shafts of the radius and ulna by the thumb and forefinger of the opposite hand, the normal lateral spring of the radial shaft will be found wanting. In children the fracture may be of the green-stick or subperiosteal type and accordingly crepitus and mobility will be absent. The shaft, however, usually shows more or less bowing in a given direction and the region of fracture

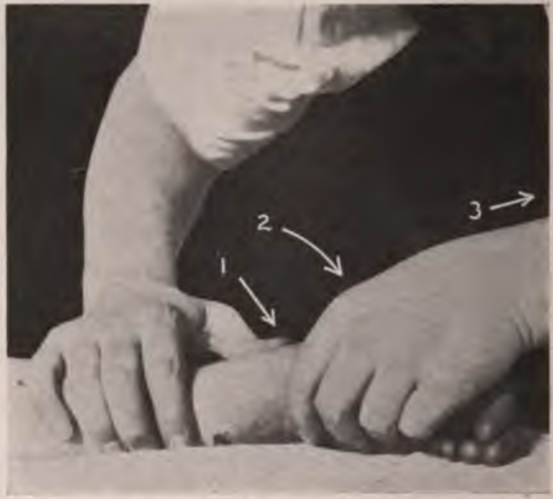


Fig. 279.—Same case showing reduction of deformity. Arrow 1 indicates the direction of pressure made by the surgeon's right hand. Arrow 2 indicates the course to be taken by the distal fragment during reduction. Arrow 3 traction made on the lower fragment while it is being brought back into position.

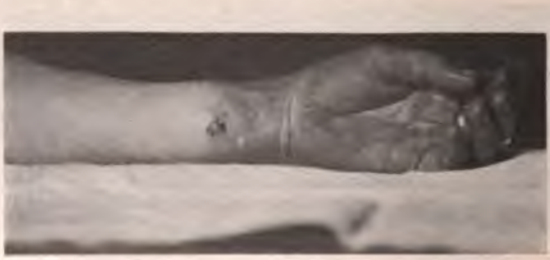


Fig. 280.—Shows ventral view of same case. Ventral prominence is evident but it will be noted that there is no displacement of the hand to either radial or ulnar sides.

will be swollen, tender and painful. Lateral pressure on the radial shaft will usually show that the normal lateral spring of the shaft is increased and will produce pain at the seat of fracture rather than at the point of pressure.

Fracture of the ulnar shaft alone is productive of symptoms similar to isolated fracture of the radial shaft except that the swelling, pain, tenderness, etc., are situated on the inner side of the forearm rather than on the radial side. Displacement is rarely pronounced as long as the radius remains intact. The posterior border of the ulnar shaft is subcutaneous throughout and unless the swelling is extreme it will be possible to determine the position of the fracture by palpation. The lower fragment is often displaced toward the radius. Shortening does not take place because the radius acts as a splint and maintains the length of the forearm. Use of the forearm is painful and lateral pressure on the shaft excites pain at the seat of fracture and not at the point of pressure.

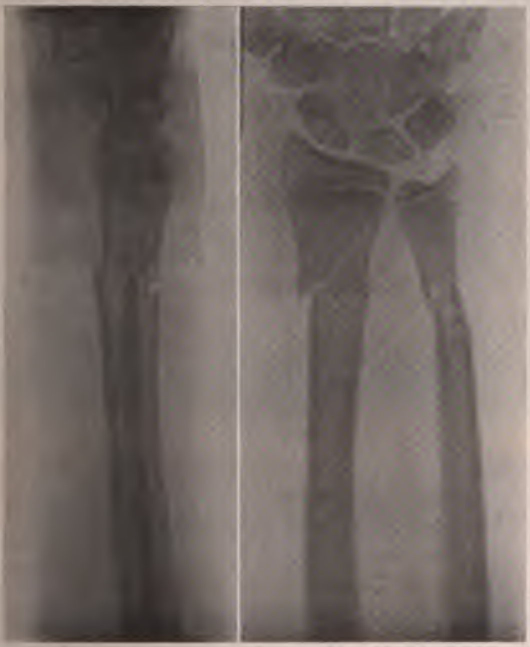


Fig. 281. Fig. 282.

Figs. 281 and 282.—Lateral and antero-posterior views of case shown in Figs. 277, 278, 279 and 280, after reduction.

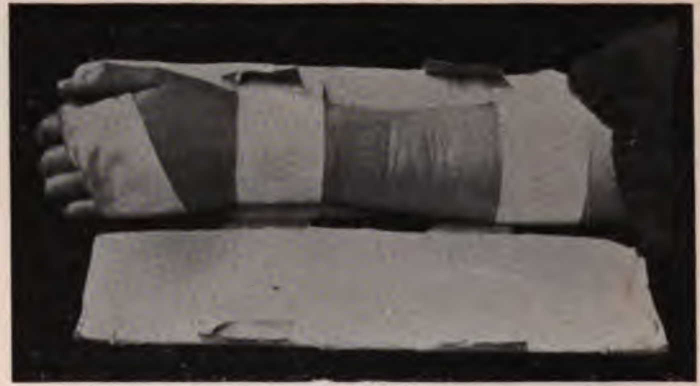


Fig. 283.

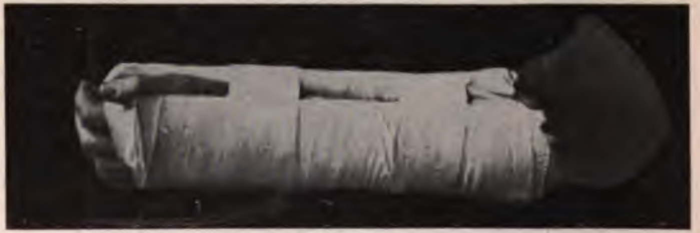


Fig. 284.

Figs. 283 and 284.—Same case as shown in Figs. 278 and 279 after reduction has been accomplished and splints applied. It will be noted that the posterior splint may be removed for examination of the forearm without disturbing the fixation of the forearm which is still firmly bound to anterior splint. Yucca board has been used in making these splints and serves the purpose admirably but should not be used unless one is experienced in the treatment of these cases and the forearm is closely watched for symptoms of strangulation. (See text.)

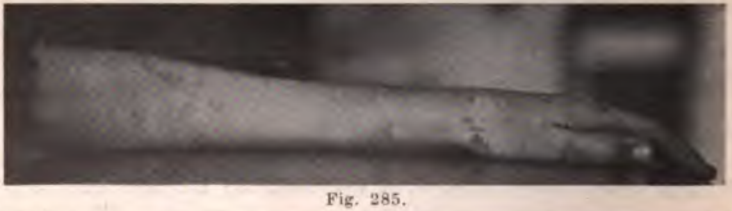


Fig. 285.

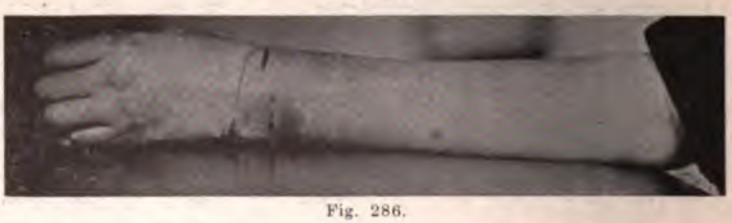


Fig. 286.

Figs. 285 and 286.—Same case at the time the splints were removed.

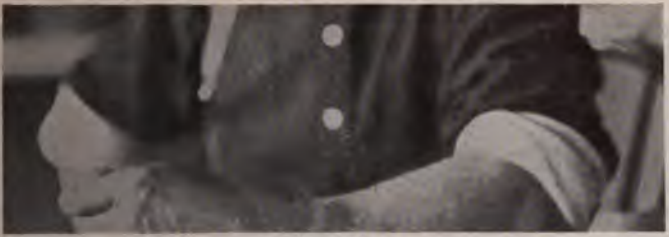


Fig. 287.

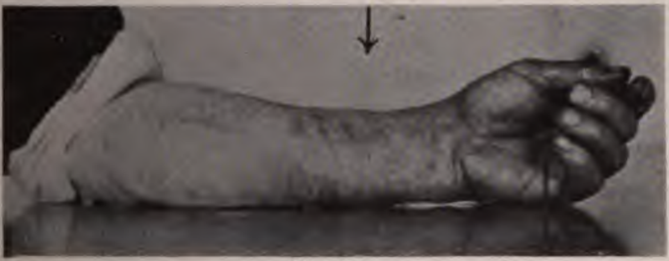


Fig. 288.

Figs. 287 and 288.—Slightly oblique fracture of radius about three inches above wrist. Lower fragment displaced toward ulna. Note the increased curve in the radial side of forearm and the slight displacement of the hand to the radial side. (Compare with Figs. 290 and 291.) Reduction difficult as lower fragment persisted in slipping out of place. Operation performed after two attempts at reduction. Fragments wired. Recovery perfect. (See X-rays shown in Figs. 292 to 297.)

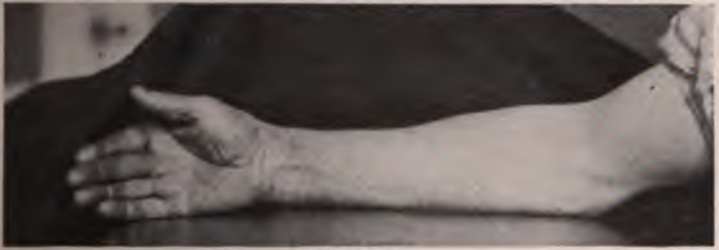


Fig. 289.

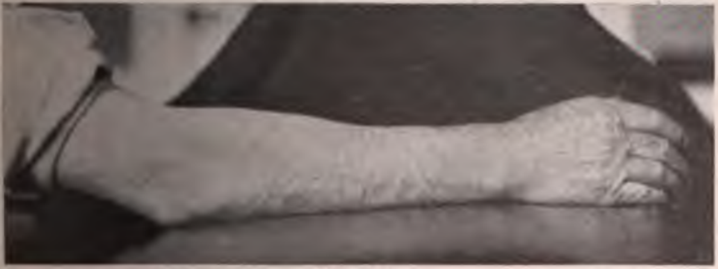
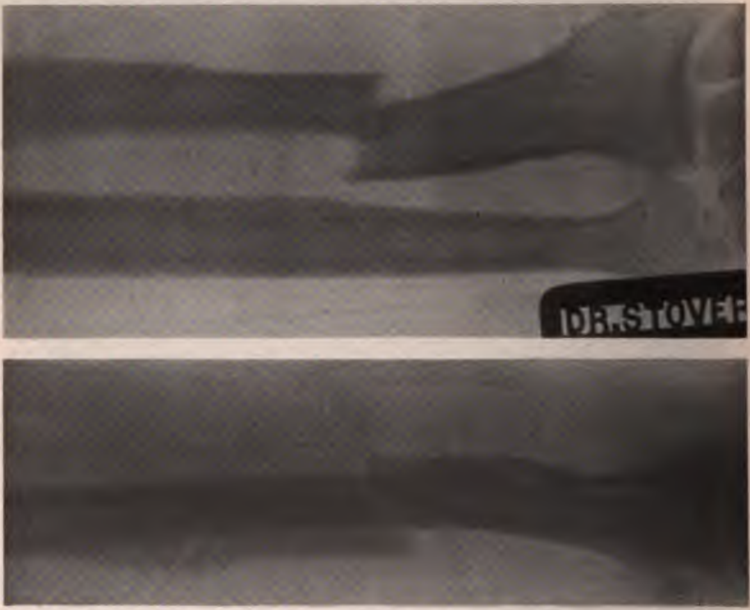
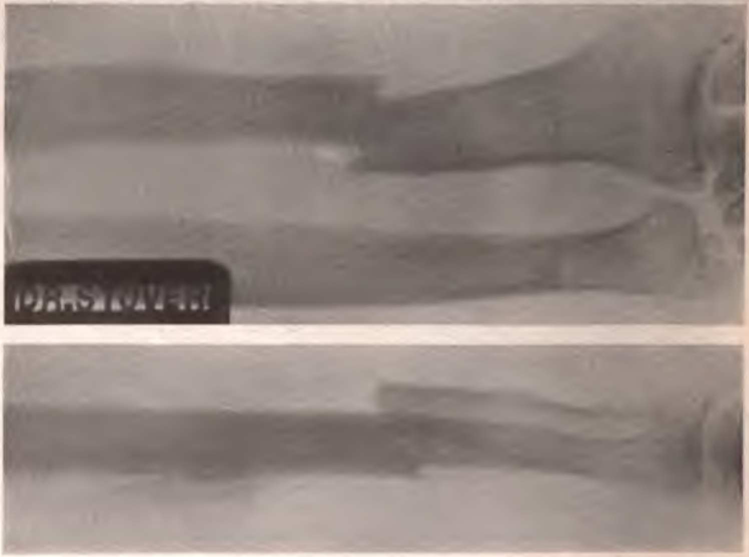


Fig. 290.

Figs. 289 and 290.—Two views of the opposite arm taken for comparison. Note the normal curve on the radial surface of the forearm as compared with that seen in Figs. 288 and 289.



Figs. 291 and 292.—Antero-posterior and lateral views of fracture of radius with recurrence of deformity after reduction. Same case as shown in Figs. 287 and 288.



Figs. 293 and 294.—Shows same case after a second reduction and recurrence of deformity.

heavy aponeurosis attached to the posterior border tends to ent lateral displacement.

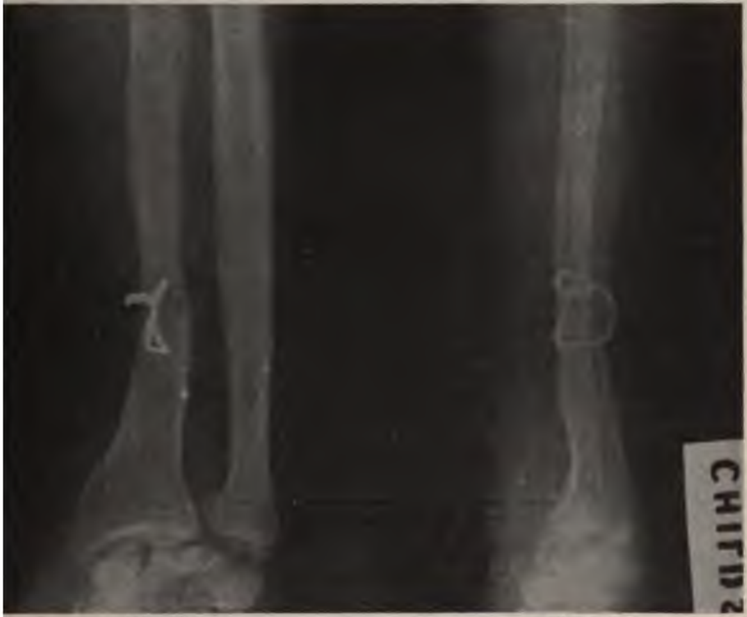


Fig. 295. Fig. 296.

Figs. 295 and 296.—Same case after operation showing correction of deformity and ing of fragments in position by means of a loop of silver wire.

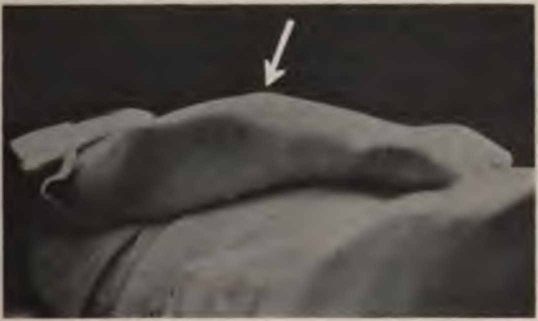


Fig. 297.—Fracture of both bones of the right forearm in a child two and a half of age. The deformity in this case is unusual in that the forearm is bowed back-. Photograph taken before reduction and about one hour following accident.

hen both bones are broken the deformity is usually pronounced may be of either the overriding or angular type. The bones he forearm may be displaced in any direction but the common deformity consists in a backward bending of the forearm;—the dorsal surface of the forearm forms an obtuse angle while the ventral surface forms the salient angle. A much less common displacement is that shown in Fig. 297 in which the forearm is bent forward instead of backward. Forward or backward displacement may take place and be pronounced without any element of overriding in either bone. When however the hand and lower part

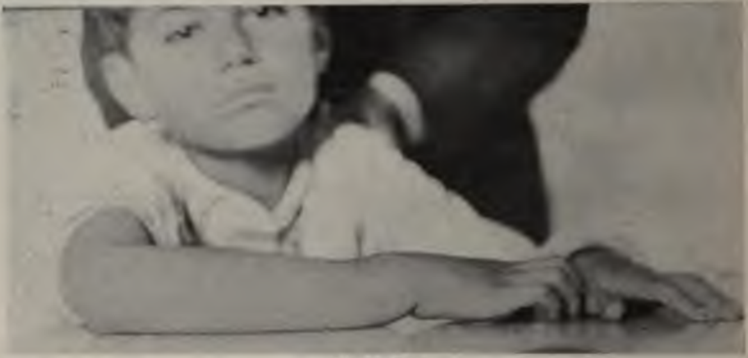


Fig. 298.

Fig. 299.

Figs. 298 and 299.—Fracture of both bones of the forearm seen from radial and ulnar sides. The fractures are so low that the condition is likely to be confounded with Colles' fracture. It will be noted, however, that the ulnar deformity begins at a higher level in this case than it does in Colles' fracture. The level of the ulnar fracture is not as apparent by inspection as it is when palpated. The lower ulnar fragment may be felt displaced backward.

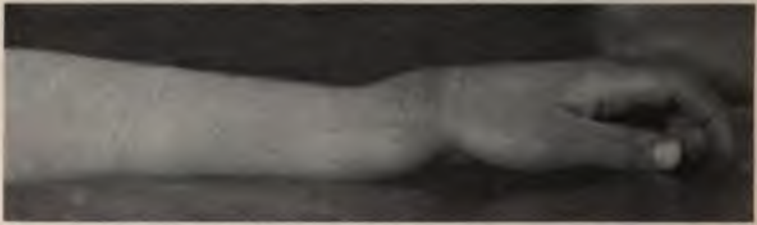


Fig. 300.—Fracture of both bones of the forearm near the wrist. Condition closely resembles Colles' fracture. Inspection and palpation of the ulnar side of the wrist discloses the break in the ulna and the backward displacement of the lower fragment.

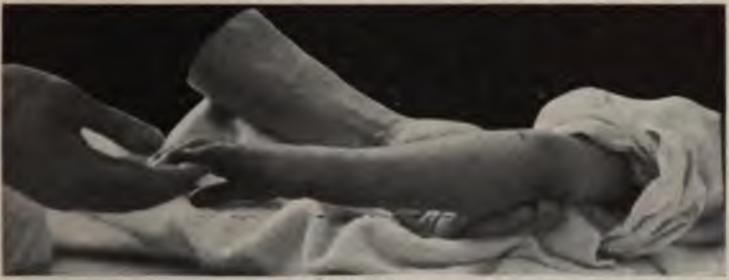


Fig. 301.

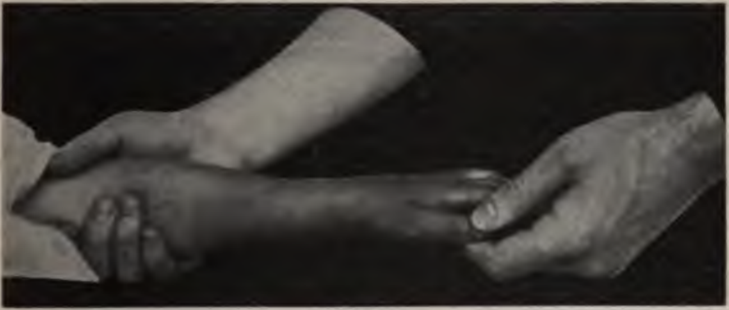


Fig. 302.

Figs. 301 and 302.—Fracture of both bones of the forearm a short distance above the wrist with very slight deformity. Note the slight backward bending of the forearm.

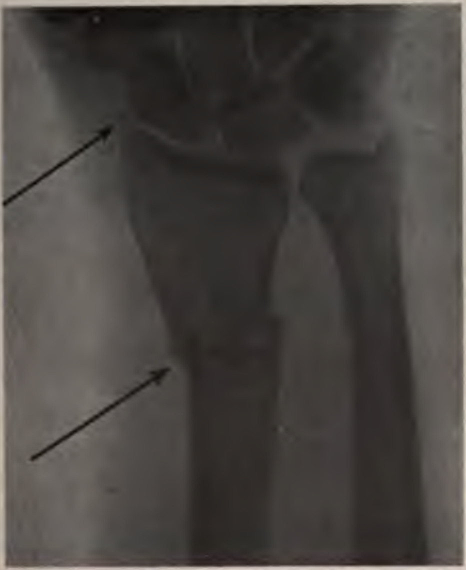


Fig. 303.—Upper arrow points to free radial styloid (anomalous). Lower arrow points to fracture of the shaft of the radius.

of the forearm are displaced to either the radial or ulnar side, the bone on the concave side of the forearm will usually show over-riding deformity. If the displacement is a combination of antero-posterior and lateral (for example, if the hand is displaced backward and also to the radial side) it will be due either to over-riding and angular deformity of the shaft on the concave side of the forearm, or else the fractures are at different levels and the forearm folds back diagonally. The nature of the deformity and the crease on the dorsal surface of the forearm will usually indicate the relative levels of the two fractures. This crease represents the apex of the angle of displacement and when the fractures are at the same level the crease will run transversely across the back of the forearm. When the fractures are at different levels the

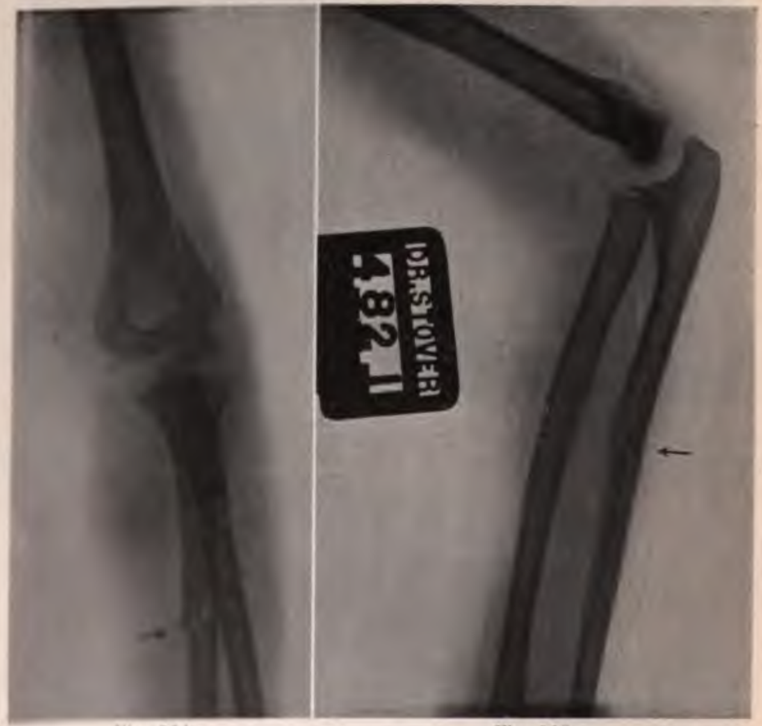


Fig. 304. Fig. 305.

Figs. 304 and 305.—Green-stick fracture of the ulna in a child. This condition might be easily overlooked if the X-ray had not been employed. Lateral compression of the two bones, however, showed more "spring" than normal in the ulnar shaft. (See Fig. 307.) Comparison with the opposite ulna renders recognition of the condition easier.

crease will be more or less obliquely placed. It is well shown in Figs. 271 and 277. In some instances the fragments of both bones will show only overriding deformity with thickening of the forearm where the fragments overlap. This thickening is often difficult to distinguish from the usual swelling at the site of fracture, but the accompanying shortening of the forearm and the resultant flail-like condition will disclose the nature of the injury. An excellent example of this condition is shown in Figs. 313 and 314. The loss of function is complete when both bones are broken and the attitude in which the patient supports the entire length of the forearm with the opposite member is characteristic.

In "green-stick" fractures of the forearm there is more or less bowing of the shafts of both bones, as a rule, either forward or backward. The deformity is seldom as distinctly angular as seen in adults but presents more of a curved effect. The condition is not flail-like and mobility is absent. The lateral spring of both bones, however, is usually increased. This increase in spring is particularly noticeable if pressure is made on the concave side of the deformity. The symptoms in children are occasionally quite mild, producing little more in the way of disability than would result from a bad sprain or bruising of the forearm. This fact calls attention to the necessity of a careful examination and the use of the X-ray in doubtful cases following injury of the forearm in a child.

Diagnosis.—In making a diagnosis of fracture of the forearm the parts should be carefully and systematically examined. There is much which can be learned by inspection alone since the majority of fractures in this region are accompanied by characteristic deformities, as shown in the accompanying illustrations. The more the surgeon can gather by inspection the less there will remain to be determined by palpation and the shorter will be manipulation which only increases the damage to the already traumatized soft tissues. The deformities shown in the accompanying illustrations are not exceptional but represent the average run of cases, and a study of these photographs should be of service to the student in enabling him to recognize these conditions with the least possible disturbance of the parts. It is always advisable to have a Röntgenogram taken of the case to determine the accuracy of reduction, if not for the purposes of establishing a diagnosis. Theoretically an X-ray examination is of great value before reduction is attempted, but practically the time necessary to secure such an examination often renders it inexpedient. The longer the deformity exists the greater the suffering and the more pronounced the secondary traumatic reaction. It is therefore incumbent on the surgeon to effect reduction at the earliest possible moment and to learn all that is possible by inspection and palpation before the fragments are brought back into alignment. When one is accustomed to interpreting these deformities a successful reduction will often be possible before the X-ray is made, while, on the other hand, if these physical signs are neglected a secondary manipulation will usually be needed after the X-ray returns are available.

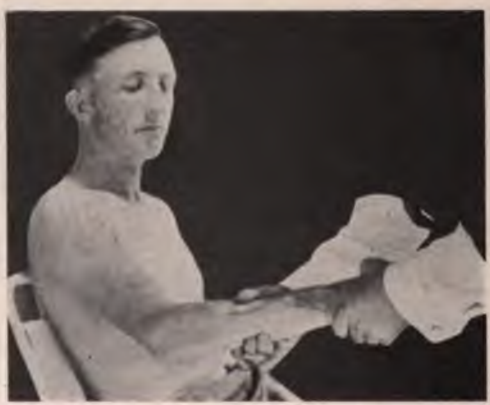


Fig. 306.—Testing the spring in the bones of the forearm by means of lateral pressure.

Treatment.—*Reduction of isolated fractures of the radius* may be easy or difficult according to the nature of the break and the displacement present. When the fracture is high, the anterior displacing action of the biceps may require immobilization in a position just short of acute flexion. (See Fig. 210 and page 145 under Treatment of "Fractures of the Lower End of the Humerus.") If the fracture is between the insertions of the biceps and pronator radii teres the condition is usually best treated with the forearm in a position of semiflexion and complete supination. (See "Anatomy" on page 205.) This places the lower fragment in a position of supination to correspond to the upper fragment which has been supinated by the biceps and supinator brevis. If the fracture in the radius is low, the upper end of the lower fragment may be displaced toward the ulna; strong traction on the wrist with adduction of the hand may be necessary to bring the lower fragment back into alignment. If reduction cannot be effected by manipulation operation is indicated. When the fracture is high the elbow should be immobilized, and when near the wrist it may be necessary to include the hand in the splint. The splints to be used and the precautions to be observed in applying them are the same as will be described shortly in the treatment of fractures of the shafts of both bones of the forearm. In instances in which the serrations are coarse there may be difficulty in securing a satisfactory engagement. Under these conditions reduction may sometimes be facilitated by temporarily increasing the angular deformity while attempting to engage the fractured ends. With the ends thus engaged the angular deformity is easily corrected since the ulna maintains the length of the forearm.

The reduction of isolated fractures of the ulnar shaft is accomplished in a manner similar to that employed in fractures of the radial shaft. Reduction is usually not attended by much difficulty as long as overriding of the fragments is prevented by an intact radius. Traction on the hand can accomplish nothing. Displacement of the lower fragment toward the radius is common and is to be corrected by digital pressure between the bones. It is often possible to secure an engagement of the serrated ends so that this deformity will not recur. When the condition is compound it should be treated according to the principles laid down under the heading of "The Treatment of Compound Fractures and Luxations," on page 789.

Unfortunately *fracture of the shafts of both bones* of the forearm is much more common than fracture of either bone separately and the condition is more difficult to treat, not only because there are two bones to be reduced but because neither bone enjoys the supporting effect of the other. It is only by appreciating the different types of deformity and what they indicate that one is qualified to return the fragments to their proper positions with the greatest accuracy and dispatch. When the deformity is purely angular and the fractures approximately transverse there will seldom be any difficulty in effecting reduction. When however there is overriding of one or both pairs of fragments correction of the displacement is much more difficult. The overriding deformity should be reduced before the angular displacement is corrected. One is thus enabled to secure an engagement of the serrated ends before the fragments are brought back into alignment. It should be remembered during all manipulations that the sharp serrated ends of the fragments may be made to do serious injury to the soft tissues. When it is found necessary to make lateral pressure on a fragment the force should be applied a little above or below the seat of fracture, as the case may be, and not directly on the displaced end. Fracture of the radius between the insertions of the biceps and pronator radii teres, calls for immobilization of the forearm in the supinated position, the same as already mentioned in the treatment of isolated fractures of the radial shaft. When the fragments of only one shaft are found to be overriding (more often the radius) our attention may be confined almost entirely to correcting the deformity of this one bone. The lateral displacement is first reduced and then the angular deformity; the opposite bone will follow provided it shows only angular displacement. When reduction is difficult or the patient nervous and hard to control it may be advisable to accomplish reduction under anesthesia. It is well to remember that children are not as safe subjects for anesthesia as adults and reduction in many cases entails only an instant of pain if properly performed. In reducing green-stick fractures in children it may be possible to simply correct the bowing and straighten the bone but more often it will be found necessary to complete the fracture by bending the shaft in the direction of the bowing and then treating the condition as a complete fracture.

If the surgeon has reason to anticipate any special difficulty in effecting reduction it may be well to prepare for operation before giving the anesthetic, and then if it is found that reduction cannot be accomplished by manipulation he is ready to correct the displacement by open incision. Thus an additional anesthetic is avoided, time is saved and there are no failures to be explained.

The splints employed in immobilization of fractures of the forearm are the same whether one or both bones are broken. Flat anterior and posterior splints will be found to meet the requirements in the largest number of cases. They should be a little broader than the widest portion of the forearm and well padded before being applied. Light quarter-inch wood will answer the purpose well. Pliable wood such as yucca board may be employed but should be used with the greatest caution and must never be bandaged in place tightly enough to force it to conform to the

APPLICATION OF SPLINTS TO THE FOREARM.

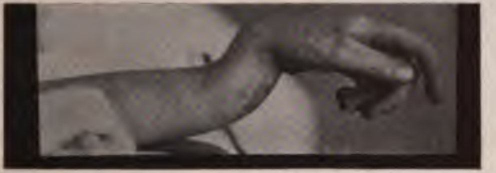


Fig. 307.—Fracture of both bones of the forearm prior to reduction. (See Figs. 385 and 386.)

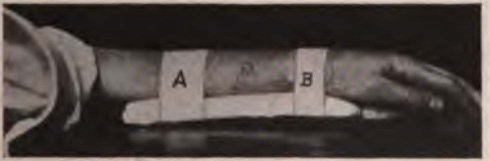


Fig. 308.—Ventral splint applied following reduction and held in position by two straps of adhesive—*A*. and *B*.

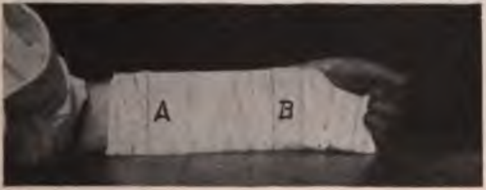


Fig. 309.—Forearm turned so that thenar "cut-out" may be seen.

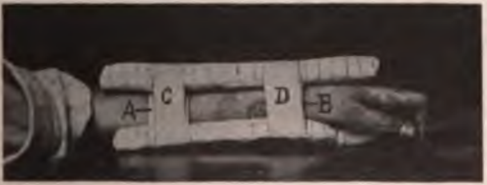


Fig. 310.—Dorsal splint applied and held in position by two additional straps of adhesive—*C*, and *D*.

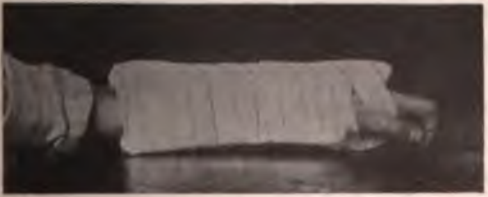


Fig. 311.—Bandaging covering both splints. When the forearm is broken above the middle this dressing should be supplemented by an internal right angle splint. (See Fig. 213.)

contour of the forearm, as otherwise constriction may result. The anterior splint should extend from the middle of the palm of the hand to a point just below the bend of the elbow when the forearm is semiflexed. The radial side of the lower end of the splint should be cut away to clear the thenar eminence as shown in Fig. 309. The cotton padding should be thicker just above the wrist and opposite the palm of the hand. The posterior splint should extend from the metacarpo-phalangeal knuckles to a point a short distance below the elbow. The forearm must not be bandaged before the splints are applied as the circulation may thus be interfered with. One splint is put in place (usually the palmar) and secured with two strips of adhesive as shown in Fig. 308 and the parts examined to see that reduction is maintained. The second splint is then applied and secured with strips of adhesive which encircle both splints. The splints should be loosely bandaged, especially when the dressing is first applied. Gangrene of the forearm or Volkmann's contracture may follow too tight bandaging, and the surgeon cannot always depend on the sensations of the patient to give warning that damage is being done. Gangrene is known to have occurred without attracting the patient's attention. Phlegmonous inflammation is not uncommon, and pus developing within the tissues may cause extensive damage by burrowing. It must be remembered in this connection that a bandage may be of the proper snugness at the time of application and yet a few hours of swelling may result in dangerous strangulation of the forearm. Any form of splint which is curved to conform to the surface of the forearm, or a rolled bandage applied to the forearm before flat splints are put in place, is more likely to produce strangulation than is the simple flat splint. Splints making pressure between the bones of the forearm to

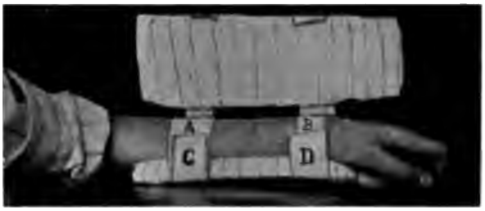


Fig. 312.—Shows same dressing opened up for inspection during the after-treatment. Straps *C.* and *D.* have been cut and dorsal splint turned back, thus allowing inspection and palpation of the forearm while it is still secured to the ventral splint. (See also Figs. 283 and 284.)

prevent approximation of the fragments across the interosseous space are dangerous and should never be used. If the fracture or fractures are in the upper half of the forearm an internal or external right angle splint should be used in addition to the flat splints employed in immobilizing the forearm. If the break is near the elbow it will be impossible to secure proper fixation without immobilizing the elbow. The thumb and fingers should be left exposed in all cases so that the condition of the circulation may be known without removing the dressings.

The secondary traumatic reaction is often pronounced in fractures of the forearm, and must be taken into consideration in the treatment of fractures in this region. If the trauma to the soft tissues is great it may be best to defer the application of splints until the swelling is decreasing and under control. It is often possible to foretell approximately the degree of swelling which will follow, by the extent of bruising of the tissues of the forearm, and when the surgeon has reason to anticipate a severe reaction the case should be treated for the first few days along the following lines. The deformity is reduced immediately and the forearm loosely bandaged on a single splint. The patient is then put to bed, the parts kept perfectly quiet and the ice cap applied at intervals to the region of fracture. Sedatives or opiates may be necessary if the pain is severe. The arm should be examined every few hours to see that the swelling is not great enough to cause constriction of the forearm within the bandages. During this time an X-ray should be taken to determine the exact nature of the fracture. When the swelling is well subsided the arm may be immobilized with splints as previously described.

Operative Treatment.—The open method is indicated in recent cases when proper reduction cannot be had by manipulation and in compound cases. Simple angular deformity can, as a rule, be corrected by manipulation unless some of the soft tissues become interposed between the fractured surfaces. Overriding deformity of one or both bones and multiple fracture of one of the shafts are the conditions most often rendering operation necessary. *Fracture of the radius* is best exposed through a longitudinal incision on the outer aspect of the forearm. The skin, fasciæ and aponeuroses are divided with the scalpel and the underlying muscles separated by blunt dissection. When the fracture is low in the radial shaft care should be taken not to divide the tendons of the extensor muscles of the thumb which pass obliquely across the outer aspect of the radius. The position of the radial pulse should be noted before making the incision to avoid injury to the artery when anomalously placed. With the fragments exposed reduction is accomplished by direct manipulation and the serrations fitted accurately together. Internal fixation will usually be unnecessary if the ulna has not been injured. Not infrequently one or both fragments show a disposition to slip out of place toward the ulna. When this occurs it may be possible to prevent recurrence of deformity by a single loop of wire holding the fractured surfaces opposed or it may be necessary to employ a small, light Lane plate.

In operating on the ulnar shaft it is best to expose the fragments through a longitudinal incision a little internal to the posterior subcutaneous border. The fragments are reduced in a manner similar to that just described in operating on the radial shaft, and internal fixation used or not, according to the needs of the case in hand.

When both bones are fractured the shafts should be exposed through two incisions as already described in operating on isolated fractures of either shaft. It is a mistake to attempt to expose both shafts through one incision since the injury to the soft tissues will be more extensive. Theoretically this would not seem to be the case, but practically it will be found to be true. Internal fixation is more frequently necessary when both bones are fractured than in instances of isolated fracture of either the radial or ulnar shaft.

In severe compound cases where there has been considerable loss of bony tissue in one of the shafts it has often been found necessary to resect a portion of the opposite shaft to make the two bones of equal length. This procedure has in many instances resulted in useful arms which would otherwise have been severely crippled, but before it is employed in any given case we should consider the possibility of an autoplastic transplantation of a portion of the shaft of the patient's fibula or a section of the tibial crest into the shaft of the deficient bone. (See "Bone Transplantation" on page 771.)

Severe compound cases should be treated according to the principles laid down under the heading of "The Treatment of Compound Fractures and Luxations" on page 789. Severed arteries

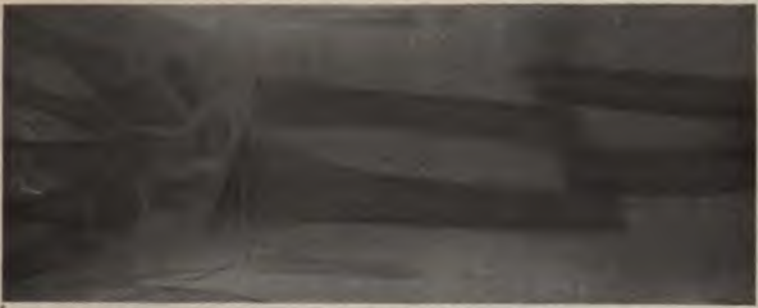


Fig. 313.—Antero-posterior view of fracture of both bones of the forearm with overriding deformity. Non-operative reduction impossible.

Fig. 314.—Lateral view of same case.

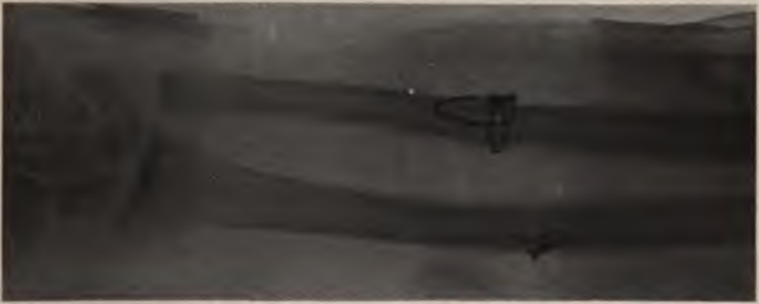


Fig. 315.—Antero-posterior view of same case after operation and internal fixation.

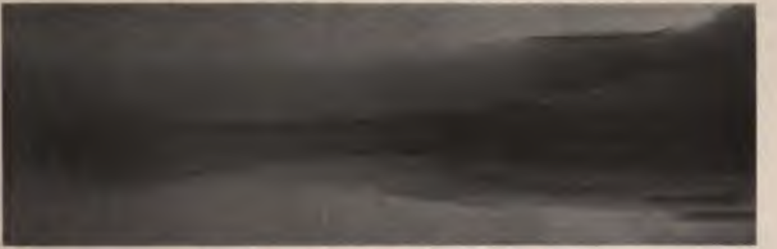


Fig. 316.—Lateral view after operation.

should be ligated and nerves sutured in cases where they are found divided.

After-Treatment.—During the first few days the bandages should be very loose and the dressings frequently inspected to see that there is no strangulation of the parts. The condition of the circulation beneath the nails may be easily ascertained and compared with the opposite side. There is no region in the body in which strangulation is more likely to take place than in the forearm and the results may be disastrous. Volkmann's contracture is a possibility which must be kept constantly in mind during the after-treatment of fractures of the forearm. (See "Volkmann's Contracture," page 231.) The skin over the head of the ulna often calls for special care to avoid irritation. Gentle massage after the subsidence of the traumatic swelling is of great value in keeping the soft tissues in good condition during the process of bone healing but the greatest care should be exercised to avoid disturbing the fragments. Union may be expected in children in three weeks or even less, but the forearm should be protected by retaining the posterior splint for another ten days. The forearm should be subjected to only the gentlest use for two or three weeks following the removal of all splints. Active motion in all directions will be weak and limited on removal of the splints, but function will return rapidly with use and massage. The parts should be inspected at least daily for the first ten days to properly accommodate the dressings to the varying size of the forearm; after ten days the dressings should be removed at least twice a week to recognize and correct deformity, should it take place. If flat splints are used, as shown in Figs. 283 and 312, one splint may be removed without disturbing the other, and we are thus enabled to inspect the parts without entirely removing the support from the broken bones. Plaster splints and the plaster cast have been successfully used in the treatment of fractures of the forearm but they are dangerous appliances except in the hands of the expert. If plaster of Paris had never been employed in the treatment of fractures of the forearm Volkmann's contracture would have been much less common.

If the fractures are at or above the middle of the shafts the internal or external right angle splint should be retained throughout as a necessary part of the dressing.

Bowing may result from using the forearm too soon and the patient should be warned to avoid undue strain on the bones for a period varying from one to four months following fracture. When there is doubt as to the satisfactory ossification of the callus it is advisable to base our after-treatment on X-ray findings. In adults four to five weeks will be necessary before the callus is strong enough to allow permanent removal of the splints. Old persons produce bone slowly and should be allowed 15 to 20 percent more time than is allowed healthy adults. During the after-treatment the fingers should be manipulated daily, especially in old persons, as otherwise adhesions form about the tendons and muscles and between the joint surfaces, which may prove a permanent source of restricted motion.

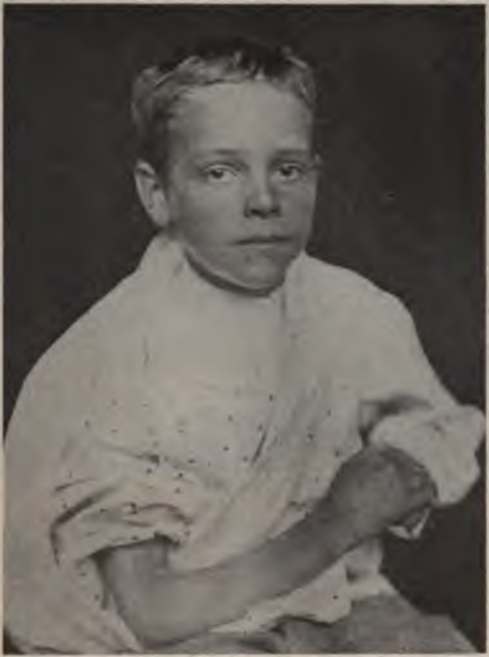


Fig. 317.—Slight bowing deformity following fracture of both bones of the forearm. The deformity here is due to overriding of the radial fragments. Note the hand which is displaced slightly to the radial side and a little backward. Operation was advised in this case but refused. Function restored but slight deformity persists. A deformity such as this will diminish with years provided the patient is young. Picture taken about four and a half weeks following fracture.

Prognosis.—The prognosis in fractures of the bones of the forearm varies greatly according to the conditions present. Accurate reduction of the fragments in a healthy child or adult should be followed by complete restoration of function. Deformity may produce loss of function. The rotary action of the forearm is most frequently interfered with, the most common causes being an outward bowing of the shaft of the radius or the extension of the callus from the shaft of the ulna to the radius when the fragments of these two bones are displaced toward each other. Loss of the power of supination may follow fracture of the radial shaft between the insertions of the biceps and pronator radii teres if not treated in supination as previously mentioned. Non-union of fractures of the forearm is not common but when it does take place it is usually the result of the interposition of soft tissues between the fractured ends rather than to constitutional causes or defective immobilization. When due to the interposition of muscle or fascia the prognosis will depend on whether or not operative procedures are instituted and the fractured surfaces brought into contact. A careful study of X-ray plates taken in two planes will as a rule disclose the presence of interposed tissues early in the course of the case, and if the proper surgical measures are then instituted

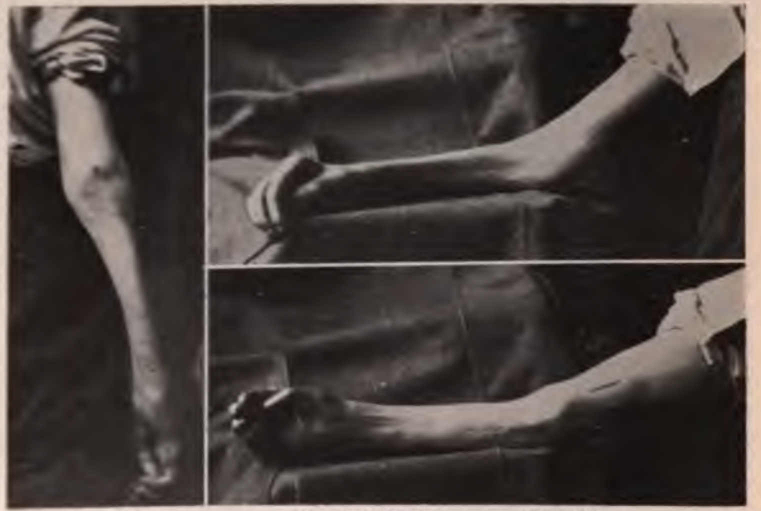


Fig. 318. Fig. 319 (top). Fig. 320.

Figs. 318, 319 and 320.—Three views of a case of Volkmann's paralysis. This case is an example of a most disastrous condition which may follow too tight bandaging of the forearm. In this case there had been no fracture. The patient sustained a lacerated wound involving one of the large arteries and an Esmarch tourniquet was applied and left in position for over twelve hours while the patient was being brought to the city for surgical treatment. Myositis, paralysis and contracture followed. Case first seen by author some years after the injury.

there will be no occasion for non-union. Slight bowing in a child will usually correct itself as years go by but this fortunate condition is no reason for the surgeon not insisting on the most perfect possible reduction following the accident.

Volkmann's paralysis (or contracture) is a paralysis of the forearm with wasting of the muscles and contracture. The first cause is said to be an ischemia which is followed by myositis and ultimate destruction of muscular tissue which is replaced by scar tissue. The function of the nerves may be subsequently destroyed by contraction of the scar tissue as well as by disuse. The points at which nerve constriction most commonly takes place are where the median passes between the heads of the pronator radii teres, and the ulnar nerve between the heads of the flexor carpi ulnaris. Volkmann's paralysis usually follows fractures of the upper extremity in children (especially fractures of the forearm) and is the result of too tight bandaging or interference with the circulation from some other cause.

Pain may be present with the onset of the condition, but is no guide whatever to the damage the forearm may be undergoing from too tight bandaging. The fingers are swollen and show passive congestion, the hand and forearm are numb and uncomfortable but seldom painful. Later on contracture develops in which the wrist is flexed, the proximal row of phalanges hyperextended and the middle and distal rows flexed. (See Figs. 318, 319 and 320.) If the condition is allowed to go uncorrected, contraction of the scar tissue replacing the muscles is likely to destroy the nerves, and all electric reaction will be lost.

If the case is seen early (within a few days or a week), massage and forcible passive motion with removal of all dressing, regardless of the presence of fracture, should be followed by complete restoration of function. If the case is first seen after the establishment of the contracture, surgical measures will be necessary, and even then the restoration of function is usually only partial. The condition of the nerves should be determined and then the procedure most likely to give good results chosen. Myotomy may be performed, the nerves may be dissected out, the flexor tendons may be lengthened or the radius and ulna may be shortened. Passive motion and massage are most important following operation.

serrated ends before the fragments are brought back into alignment. It should be remembered during all manipulations that the sharp serrated ends of the fragments may be made to do serious injury to the soft tissues. When it is found necessary to make lateral pressure on a fragment the force should be applied a little above or below the seat of fracture, as the case may be, and not directly on the displaced end. Fracture of the radius between the insertions of the biceps and pronator radii teres, calls for immobilization of the forearm in the supinated position, the same as already mentioned in the treatment of isolated fractures of the radial shaft. When the fragments of only one shaft are found to be overriding (more often the radius) our attention may be confined almost entirely to correcting the deformity of this one bone. The lateral displacement is first reduced and then the angular deformity; the opposite bone will follow provided it shows only angular displacement. When reduction is difficult or the patient nervous and hard to control it may be advisable to accomplish reduction under anesthesia. It is well to remember that children are not as safe subjects for anesthesia as adults and reduction in many cases entails only an instant of pain if properly performed. In reducing green-stick fractures in children it may be possible to simply correct the bowing and straighten the bone but more often it will be found necessary to complete the fracture by bending the shaft in the direction of the bowing and then treating the condition as a complete fracture.

If the surgeon has reason to anticipate any special difficulty in effecting reduction it may be well to prepare for operation before giving the anesthetic, and then if it is found that reduction cannot be accomplished by manipulation he is ready to correct the displacement by open incision. Thus an additional anesthetic is avoided, time is saved and there are no failures to be explained.

The splints employed in immobilization of fractures of the forearm are the same whether one or both bones are broken. Flat anterior and posterior splints will be found to meet the requirements in the largest number of cases. They should be a little broader than the widest portion of the forearm and well padded before being applied. Light quarter-inch wood will answer the purpose well. Pliable wood such as yucca board may be employed but should be used with the greatest caution and must never be bandaged in place tightly enough to force it to conform to the

APPLICATION OF SPLINTS TO THE FOREARM.

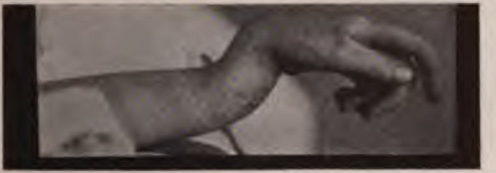


Fig. 307.—Fracture of both bones of the forearm prior to reduction. (See Figs. 385 and 386.)

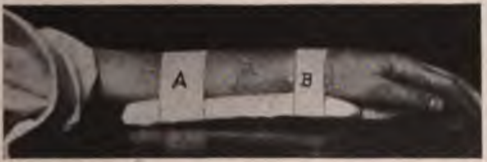


Fig. 308.—Ventral splint applied following reduction and held in position by two straps of adhesive—*A*. and *B*.

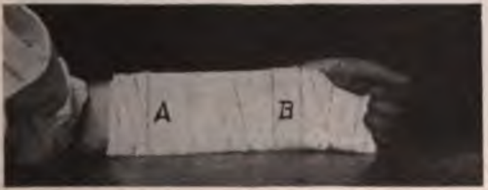


Fig. 309.—Forearm turned so that thenar "cut-out" may be seen.

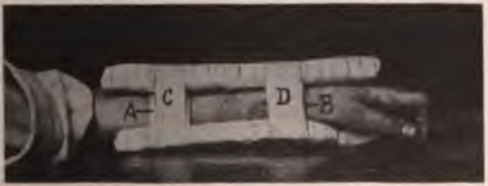


Fig. 310.—Dorsal splint applied and held in position by two additional straps of adhesive—*C*. and *D*.

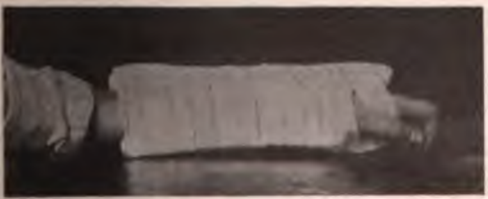


Fig. 311.—Bandaging covering both splints. When the forearm is broken above the middle this dressing should be supplemented by an internal right angle splint. (See Fig. 213.)

contour of the forearm, as otherwise constriction may result. The anterior splint should extend from the middle of the palm of the hand to a point just below the bend of the elbow when the forearm is semiflexed. The radial side of the lower end of the splint should be cut away to clear the thenar eminence as shown in Fig. 309. The cotton padding should be thicker just above the wrist and opposite the palm of the hand. The posterior splint should extend from the metacarpo-phalangeal knuckles to a point a short distance below the elbow. The forearm must not be bandaged before the splints are applied as the circulation may thus be interfered with. One splint is put in place (usually the palmar) and secured with two strips of adhesive as shown in Fig. 308 and the parts examined to see that reduction is maintained. The second splint is then applied and secured with strips of adhesive which encircle both splints. The splints should be loosely bandaged, especially when the dressing is first applied. Gangrene of the forearm or Volkmann's contracture may follow too tight bandaging, and the surgeon cannot always depend on the sensations of the patient to give warning that damage is being done. Gangrene is known to have occurred without attracting the patient's attention. Phlegmonous inflammation is not uncommon, and pus developing within the tissues may cause extensive damage by burrowing. It must be remembered in this connection that a bandage may be of the proper snugness at the time of application and yet a few hours of swelling may result in dangerous strangulation of the forearm. Any form of splint which is curved to conform to the surface of the forearm, or a rolled bandage applied to the forearm before flat splints are put in place, is more likely to produce strangulation than is the simple flat splint. Splints making pressure between the bones of the forearm to

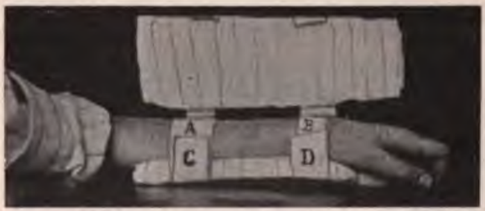


Fig. 312.—Shows same dressing opened up for inspection during the after-treatment. Straps *C.* and *D.* have been cut and dorsal splint turned back, thus allowing inspection and palpation of the forearm while it is still secured to the ventral splint. (See also Figs. 283 and 284.)

prevent approximation of the fragments across the interosseous space are dangerous and should never be used. If the fracture or fractures are in the upper half of the forearm an internal or external right angle splint should be used in addition to the flat splints employed in immobilizing the forearm. If the break is near the elbow it will be impossible to secure proper fixation without immobilizing the elbow. The thumb and fingers should be left exposed in all cases so that the condition of the circulation may be known without removing the dressings.

The secondary traumatic reaction is often pronounced in fractures of the forearm, and must be taken into consideration in the treatment of fractures in this region. If the trauma to the soft tissues is great it may be best to defer the application of splints until the swelling is decreasing and under control. It is often possible to foretell approximately the degree of swelling which will follow, by the extent of bruising of the tissues of the forearm, and when the surgeon has reason to anticipate a severe reaction the case should be treated for the first few days along the following lines. The deformity is reduced immediately and the forearm loosely bandaged on a single splint. The patient is then put to bed, the parts kept perfectly quiet and the ice cap applied at intervals to the region of fracture. Sedatives or opiates may be necessary if the pain is severe. The arm should be examined every few hours to see that the swelling is not great enough to cause constriction of the forearm within the bandages. During this time an X-ray should be taken to determine the exact nature of the fracture. When the swelling is well subsided the arm may be immobilized with splints as previously described.

Operative Treatment.—The open method is indicated in recent cases when proper reduction cannot be had by manipulation and in compound cases. Simple angular deformity can, as a rule, be corrected by manipulation unless some of the soft tissues become interposed between the fractured surfaces. Overriding deformity of one or both bones and multiple fracture of one of the shafts are the conditions most often rendering operation necessary. *Fracture of the radius* is best exposed through a longitudinal incision on the outer aspect of the forearm. The skin, fasciæ and aponeuroses are divided with the scalpel and the underlying muscles separated by blunt dissection. When the fracture is low in the radial shaft care should be taken not to divide the tendons of the extensor muscles of the thumb which pass obliquely across the outer aspect of the lower end of the radius. The position of the radial pulse should be noted before making the incision to avoid injury to the artery when anomalously placed. With the fragments exposed reduction is accomplished by direct manipulation and the serrations fitted accurately together. Internal fixation will usually be unnecessary if the ulna has not been injured. Not infrequently one or both fragments show a disposition to slip out of place toward the ulna. When this occurs it may be possible to prevent recurrence of deformity by a single loop of wire holding the fractured surfaces opposed or it may be necessary to employ a small, light Lane plate.

In operating on the ulnar shaft it is best to expose the fragments through a longitudinal incision a little internal to the posterior subcutaneous border. The fragments are reduced in a manner similar to that just described in operating on the radial shaft, and internal fixation used or not, according to the needs of the case in hand.

When both bones are fractured the shafts should be exposed through two incisions as already described in operating on isolated fractures of either shaft. It is a mistake to attempt to expose both shafts through one incision since the injury to the soft tissues will be more extensive. Theoretically this would not seem to be the case, but practically it will be found to be true. Internal fixation is more frequently necessary when both bones are fractured than in instances of isolated fracture of either the radial or ulnar shaft.

In severe compound cases where there has been considerable loss of bony tissue in one of the shafts it has often been found necessary to resect a portion of the opposite shaft to make the two bones of equal length. This procedure has in many instances resulted in useful arms which would otherwise have been severely crippled, but before it is employed in any given case we should consider the possibility of an autoplastic transplantation of a portion of the shaft of the patient's fibula or a section of the tibial crest into the shaft of the deficient bone. (See "Bone Transplantation" on page 771.)

Severe compound cases should be treated according to the principles laid down under the heading of "The Treatment of Compound Fractures and Luxations" on page 789. Severed arteries

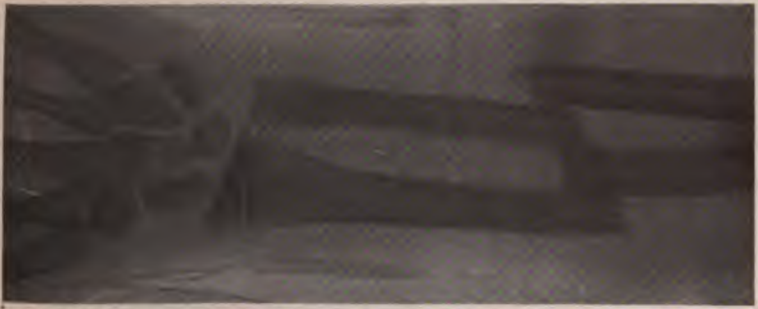


Fig. 313.—Antero-posterior view of fracture of both bones of the forearm with overriding deformity. Non-operative reduction impossible.

Fig. 314.—Lateral view of same case.

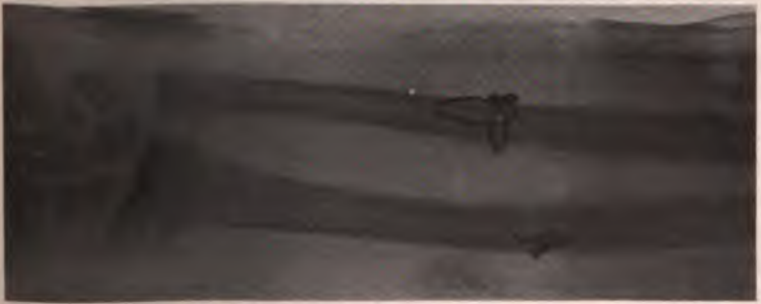


Fig. 315.—Antero-posterior view of same case after operation and internal fixation.

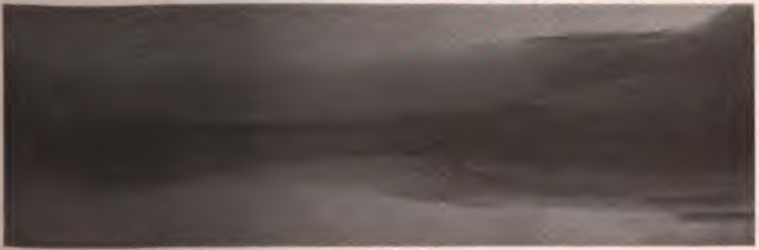


Fig. 316.—Lateral view after operation.

should be ligated and nerves sutured in cases where they are found divided.

After-Treatment.—During the first few days the bandages should be very loose and the dressings frequently inspected to see that there is no strangulation of the parts. The condition of the circulation beneath the nails may be easily ascertained and compared with the opposite side. There is no region in the body in which strangulation is more likely to take place than in the forearm and the results may be disastrous. Volkmann's contracture is a possibility which must be kept constantly in mind during the after-treatment of fractures of the forearm. (See "Volkmann's Contracture," page 231.) The skin over the head of the ulna often calls for special care to avoid irritation. Gentle massage after the subsidence of the traumatic swelling is of great value in keeping the soft tissues in good condition during the process of bone healing but the greatest care should be exercised to avoid disturbing the fragments. Union may be expected in children in three weeks or even less, but the forearm should be protected by retaining the posterior splint for another ten days. The forearm should be subjected to only the gentlest use for two or three weeks following the removal of all splints. Active motion in all directions will be weak and limited on removal of the splints, but function will return rapidly with use and massage. The parts should be inspected at least daily for the first ten days to properly accommodate the dressings to the varying size of the forearm; after ten days the dressings should be removed at least twice a week to recognize and correct deformity, should it take place. If flat splints are used, as shown in Figs. 283 and 312, one splint may be removed without disturbing the other, and we are thus enabled to inspect the parts without entirely removing the support from the broken bones. Plaster splints and the plaster cast have been successfully used in the treatment of fractures of the forearm but they are dangerous appliances except in the hands of the expert. If plaster of Paris had never been employed in the treatment of fractures of the forearm Volkmann's contracture would have been much less common.

If the fractures are at or above the middle of the shafts the internal or external right angle splint should be retained throughout as a necessary part of the dressing.

Bowing may result from using the forearm too soon and the patient should be warned to avoid undue strain on the bones for a period varying from one to four months following fracture. When there is doubt as to the satisfactory ossification of the callus it is advisable to base our after-treatment on X-ray findings. In adults four to five weeks will be necessary before the callus is strong enough to allow permanent removal of the splints. Old persons produce bone slowly and should be allowed 15 to 20 percent more time than is allowed healthy adults. During the after-treatment the fingers should be manipulated daily, especially in old persons, as otherwise adhesions form about the tendons and muscles and between the joint surfaces, which may prove a permanent source of restricted motion.

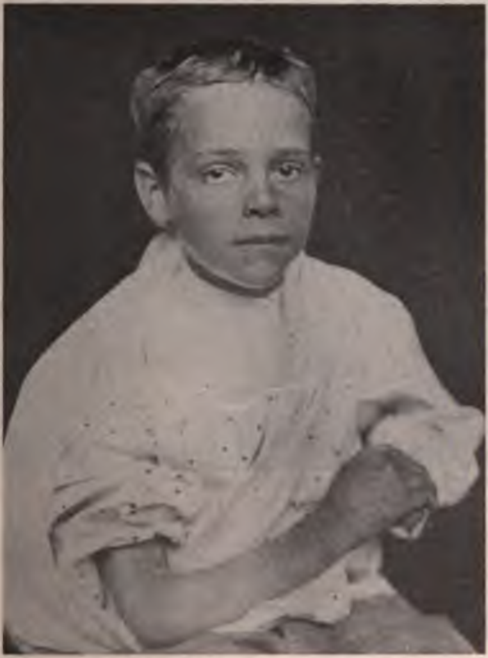


Fig. 317.—Slight bowing deformity following fracture of both bones of the forearm. The deformity here is due to overriding of the radial fragments. Note the hand which is displaced slightly to the radial side and a little backward. Operation was advised in this case but refused. Function restored but slight deformity persists. A deformity such as this will diminish with years provided the patient is young. Picture taken about four and a half weeks following fracture.

Prognosis.—The prognosis in fractures of the bones of the forearm varies greatly according to the conditions present. Accurate reduction of the fragments in a healthy child or adult should be followed by complete restoration of function. Deformity may produce loss of function. The rotary action of the forearm is most frequently interfered with, the most common causes being an outward bowing of the shaft of the radius or the extension of the callus from the shaft of the ulna to the radius when the fragments of these two bones are displaced toward each other. Loss of the power of supination may follow fracture of the radial shaft between the insertions of the biceps and pronator radii teres if not treated in supination as previously mentioned. Non-union of fractures of the forearm is not common but when it does take place it is usually the result of the interposition of soft tissues between the fractured ends rather than to constitutional causes or defective immobilization. When due to the interposition of muscle or fascia the prognosis will depend on whether or not operative procedures are instituted and the fractured surfaces brought into contact. A careful study of X-ray plates taken in two planes will as a rule disclose the presence of interposed tissues early in the course of the case, and if the proper surgical measures are then instituted

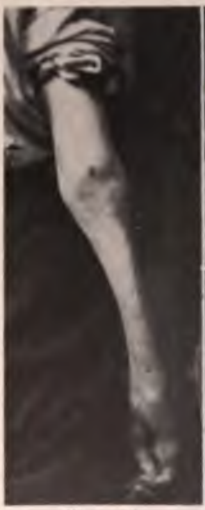


Fig. 318.

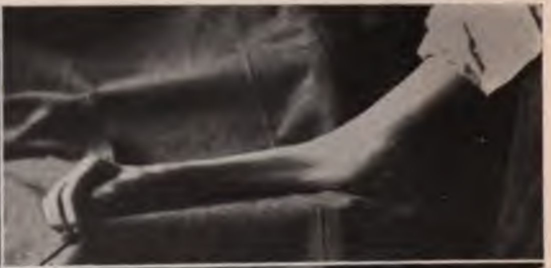


Fig. 319 (top).

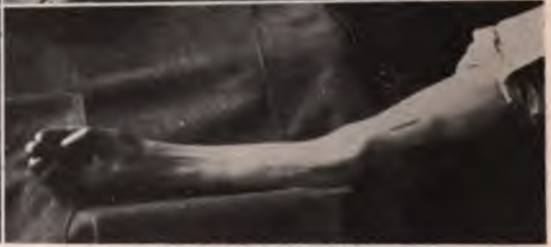


Fig. 320.

Figs. 318, 319 and 320.—Three views of a case of Volkmann's paralysis. This case is an example of a most disastrous condition which may follow too tight bandaging of the forearm. In this case there had been no fracture. The patient sustained a lacerated wound involving one of the large arteries and an Esmarch tourniquet was applied and left in position for over twelve hours while the patient was being brought to the city for surgical treatment. Myositis, paralysis and contracture followed. Case first seen by author some years after the injury.

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Volkmann's paralysis (or contracture) is a paralysis of the forearm with wasting of the muscles and contracture. The first cause is said to be an ischemia which is followed by myositis and ultimate destruction of muscular tissue which is replaced by scar tissue. The function of the nerves may be subsequently destroyed by contraction of the scar tissue as well as by disuse. The points at which nerve constriction most commonly takes place are where the median passes between the heads of the pronator radii teres, and the ulnar nerve between the heads of the flexor carpi ulnaris. Volkmann's paralysis usually follows fractures of the upper extremity in children (especially fractures of the forearm) and is the result of too tight bandaging or interference with the circulation from some other cause.

Pain may be present with the onset of the condition, but is no guide whatever to the damage the forearm may be undergoing from too tight bandaging. The fingers are swollen and show passive congestion, the hand and forearm are numb and uncomfortable but seldom painful. Later on contracture develops in which the wrist is flexed, the proximal row of phalanges hyperextended and the middle and distal rows flexed. (See Figs. 318, 319 and 320.) If the condition is allowed to go uncorrected, contraction of the scar tissue replacing the muscles is likely to destroy the nerves, and all electric reaction will be lost.

If the case is seen early (within a few days or a week), massage and forcible passive motion with removal of all dressing, regardless of the presence of fracture, should be followed by complete restoration of function. If the case is first seen after the establishment of the contracture, surgical measures will be necessary, and even then the restoration of function is usually only partial. The condition of the nerves should be determined and then the procedure most likely to give good results chosen. Myotomy may be performed, the nerves may be dissected out, the flexor tendons may be lengthened or the radius and ulna may be shortened. Passive motion and massage are most important following operation.

CHAPTER XVII.

FRACTURES OF THE LOWER END OF THE ULNA.

Surgical Anatomy.—Isolated fracture of the lower end of the ulna is not a common injury and its importance is much less than fractures of the lower end of the radius. Uncomplicated fracture in this region is almost invariably due to direct violence. The lower end of the ulna is only slightly larger than the shaft above it and transverse stress is about the only type of strain to which it is subjected. It forms the center about which the lower end of the radius revolves during supination and pronation. Longitudinal stress, such as sustained in falls on the hand, is transmitted through the radius directly to the humerus, and from the radius to the ulnar shaft by means of the interosseous membrane. The lower end of the ulna remains free from this type of strain, becoming involved only when the radius breaks; the pull of the triangular fibro-cartilage may then fracture the ulnar styloid. The lower end of the ulna does not enter into the formation of the wrist joint but articulates with the upper surface of the triangular fibro-cartilage and the sigmoid cavity of the radius. In pronation, the head of the ulna presents at the back of the wrist, while in supination the styloid process alone is palpable. Fractures of the lower end of the ulna are often situated just above the head and are usually transverse, though they may be oblique or longitudinal and involve the head or styloid process. The most common break of this portion of the ulna is seen accompanying Colles' fracture and consists in an avulsion of the styloid. (See Figs. 326 to 331.)

Epiphyseal separations may occur but are quite rare. The lower epiphysis (including the head and styloid) is ossified from a single center which is first seen about the fourth year. It joins the shaft at about the twentieth year. An anomalous ossicle, the triangulare, is sometimes seen just below the tip of the ulnar styloid and may be mistaken for fracture of this process in interpreting X-ray plates of this region. (See Figs. 405 and 406.)

On the posterior aspect of the lower end of the bone is a shallow

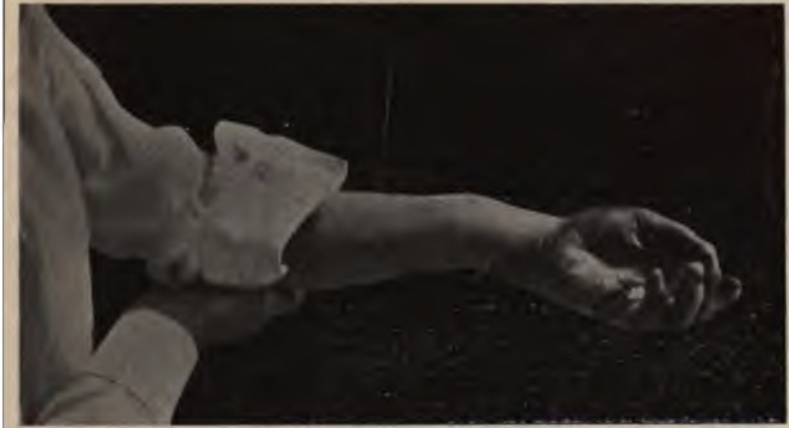

Fig. 321.—Fracture of both bones of the forearm and separation of the lower ulnar epiphysis. The separated epiphysis forms a slight prominence on the ulnar side of the wrist which may be seen and felt. Photograph taken a few minutes following accident.

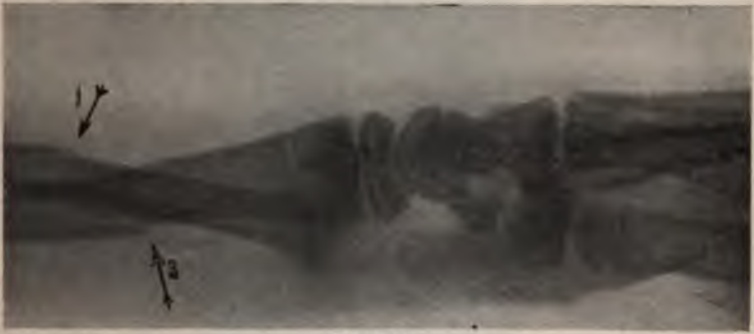

Fig. 322.

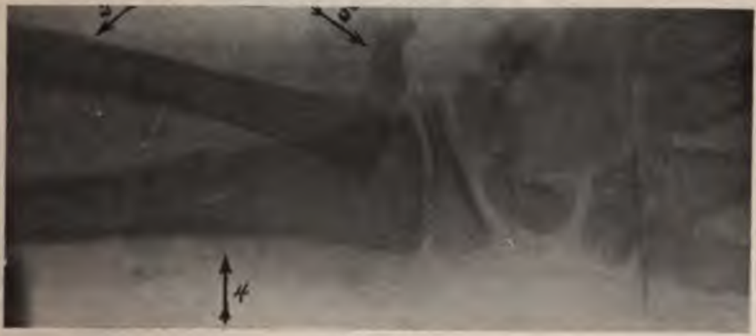

Fig. 323.

Figs. 322 and 323.—X-ray plates showing antero-posterior and lateral views of the case seen in Fig. 321. *1* and *2*, fracture in ulnar shaft; *3* and *4*, fracture in radial shaft; *5*, displaced ulnar epiphysis.

groove for the passage of the tendon of the extensor carpi ulnaris.

Symptoms.—The symptoms accompanying isolated fracture of the lower end of the ulna are often surprisingly mild. There is local pain, tenderness, swelling and a variable degree of loss of function. Since the condition usually results from direct violence there will, as a rule, be evidences of the blow on the skin in this region. If the trauma is severe the condition may be compound. Supination and pronation are often particularly painful and the wrist lacks lateral stability though the movements of the wrist itself are mechanically undisturbed. Direct palpation will elicit crepitus if the fragments are manipulated. The lower end of the upper fragment may be displaced in any direction though it is more common to find it nearer the radius than normal and prominent posteriorly. Deformity, however, is usually slight.

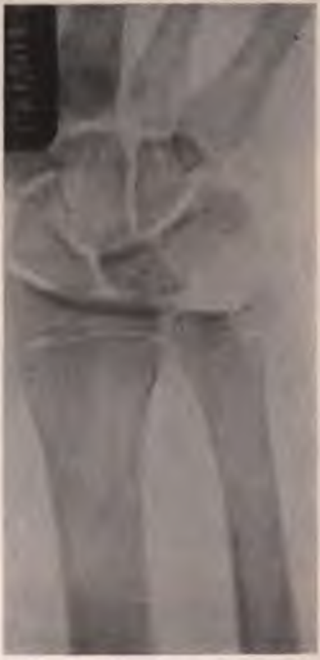

Fig. 324.—Fracture and separation of a portion of the ulnar epiphysis including the styloid process.

Diagnosis.—Fracture of the lower end of the ulna can, as a rule, be recognized without difficulty if the parts are carefully examined. There is no characteristic deformity and hence inspection alone is of little value. The condition is most frequently overlooked when it occurs accompanying Colles' fracture. The broadening of the wrist seen in Colles' fracture is due to rupture of the triangular fibro-cartilage or to avulsion of the styloid (usually the latter) and is suggestive of fracture of the lower end of the ulna. When doubt exists the X-ray should be employed.

Treatment.—This fracture is not a serious one as compared to other breaks in this region and reduction of the displacement is usually accomplished without difficulty. If the tendon of the extensor carpi ulnaris tends to displace the lower fragment the hand should be treated in a position of dorsal flexion and adduction. A single anterior splint extending from the base of the fingers to the upper part of the forearm will usually suffice in immobilizing the parts. Direct pressure may be exerted by pads of gauze secured in position by strips of adhesive plaster. Direct pressure is not often indicated, but when it is it will usually be found necessary because of a tendency on the part of the lower end of the upper fragment to backward deformity. Under these circumstances direct pressure should be exerted on the shaft of the bone above the level of the fracture. Tight bandaging is as dangerous here as in the treatment of fractures of the shafts of the bones of the forearm, and the same precautions are to be observed as already mentioned in the preceding section. The forearm should be carried in a sling which supports its entire length as otherwise it may exert a displacing action on the fragments.

Operative Treatment.—Open treatment is rarely indicated in recent cases aside from compound conditions. When the fracture is open it is to be treated according to the principles laid down under "The Treatment of Compound Fractures and Luxations," on page 789. If deformity recurs or persists and cannot be controlled by ordinary methods the fragments should be secured by internal fixation (see page 754).

After-Treatment.—The forearm should be frequently inspected during the first week or ten days, especially if the secondary traumatic reaction is pronounced. Undue constriction of the forearm is as dangerous here as in fractures of the shafts of the bones of the forearm and may lead to Volkmann's Contracture (see page 230). Immobilization for three to four weeks should result in union. Fracture of the styloid and displacement of the lower end of the ulna will be considered under "Fractures of the Lower

End of the Radius," since it most frequently occurs as a complication of Colles' fracture.

Prognosis.—The outlook in uncomplicated fracture of the lower end of the ulna is good both as to function and deformity. Fibrous union is sometimes seen but does not as a rule materially lessen function. When the condition is compound the prognosis is of course worse, but it is rare to see disability following fractures in this region.

CHAPTER XVIII.

LUXATIONS OF THE LOWER END OF THE ULNA.

Surgical Anatomy.—The lower end of the ulna articulates with the superior surface of the triangular fibro-cartilage and the sigmoid cavity of the radius. The lower end of the radius describes an arc about the head of the ulna during supination and pronation and the center of the arc thus described is the attachment of the apex of the triangular fibro-cartilage in the depression between the ulnar head and styloid. This triangular cartilage is the only ligament in the lower radio-ulnar articulation which maintains the ends of the bones in apposition. The anterior and posterior radio-ulnar ligaments extend transversely in front of, and behind, the joint and limit its rotary action. The lower end of the ulna does not enter into the formation of the wrist joint. A separate synovial sac exists between the lower end of the ulna and the cartilage, and extends upward between the radius and ulna. Isolated luxation of the lower end of the ulna is an extremely rare accident though it has been recorded in a sufficient number of cases to establish it as a type. A more or less complete dislocation of this joint is not an uncommon complication of Colles' fracture and is the result of rupture of the triangular fibro-cartilage or an avulsion of its ulnar attachment. This condition has been fully considered under "Fractures of the Lower End of the Radius," (page 242), and appropriately so, since it is secondary to and a complication of Colles' fracture.

It is probable that no one observer has seen more than one uncomplicated luxation of the lower end of the ulna and hence the details of the condition are not as well known as they might be. The author has seen but one case. Experiments which the author has conducted on the cadaver showed that rupture of the triangular fibro-cartilage or avulsion of one of its attachments was necessary for inward luxation. Rupture of the posterior radio-ulnar ligament was regularly found in posterior dislocations and tearing of the anterior ligament was noted in forward luxations.

Extreme pronation produced tension on the posterior fibres of the triangular fibro-cartilage while extreme supination rendered the anterior fibres taut. Reduction was accompanied by a distinct snap in all cases in which the triangular fibro-cartilage remained unruptured.

Clinically, three types of luxation of the lower end of the ulna have been observed:—namely, backward, forward and inward. *In the backward type* the head occupies a position just behind the postero-internal angle of the quadrilateral lower end of the radius. The posterior ligament is torn while the triangular fibro-cartilage remains intact. This type of luxation is more commonly seen as a complication of "reversed Colles' fracture" and is due to hyperpronation of the wrist. *In the forward type* of luxation the lower end of the ulna is displaced forward and slightly outward, and in isolated cases is probably caused by hypersupination. As a complication of fracture of the lower end of the radius it is not uncommon. *The inward type* occurs only with rupture of the interarticular cartilage and as an isolated injury is so rare as to be questionable. As a complication of Colles' fracture it is not at all uncommon.

Symptoms.—The symptoms accompanying luxations of the lower end of the ulna depend on the length of time the displacement has persisted and the position occupied by the head of the ulna. In recent cases there is pain, swelling, tenderness, loss of function, etc. The deformity and disturbance in function depend on the type of luxation. *In the backward variety* the wrist is in extreme pronation, narrower than normal and the prominence of the displaced head is apparent. The hand is slightly adducted,

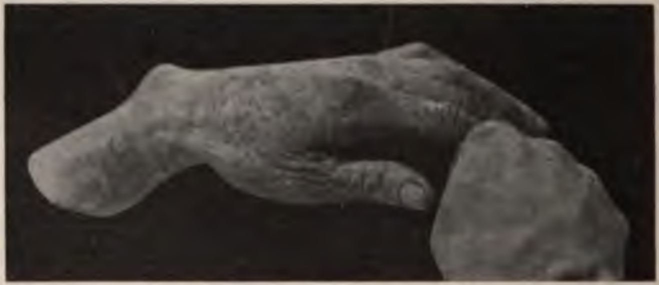

Fig. 325.—Posterior luxation of lower end of ulna. Note the abnormal prominence at the back of the wrist on the ulnar side.

supination is impossible as long as the luxation exists, and there is loss of power in the fingers and wrist. *In the forward type* the forearm is fixed in supination and the ulnar head may be palpated on the palmar aspect of the wrist above the pisiform. The wrist appears narrower than normal and the absence of the ulnar head from its normal position is apparent. *The inward type* of luxation shows a broadening of the wrist with loss of power in the rotary action of the forearm. The symptoms of inward luxation are a part of the clinical picture in many cases of Colles' fracture, and as such have been described under "Fractures of the Lower End of the Radius." As an isolated injury this dislocation is a surgical curiosity.

Chronic and recurrent luxations of the lower end of the ulna are occasionally seen and the symptoms differ considerably from the acute condition. A chronic backward subluxation is sometimes seen in children as a result of heavy work while the bones are still in a soft and developmental stage and is known as Madelung's deformity. This backward displacement develops gradually as the radial deformity increases, and with removal of longitudinal pressure the ulna grows proportionately faster than the radius.

Recurrent luxation of the lower end of the ulna is an extremely rare condition sometimes seen following trauma in this region. The displacement is usually not pronounced, but the lower end of the ulna is likely to slip out of position with extreme supination or pronation. Reduction is easy and usually accomplished by the patient. The annoyance and interference with function may be marked and is sometimes accompanied by ulnar neuritis.

Diagnosis.—There should be little difficulty in recognizing dislocations of the lower end of the ulna. The displaced head of the bone may be palpated and is characteristic of the luxation according to the direction of displacement. In the forward type the wrist is narrower than normal and fixed in supination. In the backward type it is narrower than normal and fixed in pronation. The broadening of the wrist is typical of inward luxations which are almost never seen except as a complication of Colles' fracture. Luxations of this joint are most frequently overlooked when they exist as complications of Colles' fracture, and this is because one is apt to feel that the diagnosis is complete as soon as the fracture has been recognized.

Treatment.—The method of reduction will depend on the type of luxation present. In backward dislocations pressure should be exerted with the thumbs to force the lower ends of the bones apart while the wrist is being carried into supination. The object is to force the head of the ulna around the postero-internal angle of the lower end of the radius and then carry the forearm into supination. Reduction is accompanied by a distinct snap as the ulnar head clears the prominence and settles back into the sigmoid cavity of the radius. Reduction of the anterior luxation is accomplished by forcing the ulnar head backward and inward around the antero-internal angle of the lower end of the radius and then carrying the forearm into pronation. Reduction of this luxation is also accompanied by a distinct snap if the triangular fibro-cartilage is not ruptured. Uncomplicated inward luxation of the head of the ulna would probably offer little or no resistance to reduction and the tendency to recurrence would be slight. The condition, however, is practically unknown as an isolated injury. When it occurs as a complication of Colles' fracture it is difficult to keep the luxated ulnar head in position because the radius has been shortened by fracture. In recent cases there is little tendency to recurrence of deformity if the luxation is either forward or backward. In old cases it may be impossible to effect reduction by manipulation, especially if the ulna has outgrown the radius in length.

Operative Treatment.—Operative treatment is practically never indicated in recent cases unless the condition is a complication of Colles' fracture and the break calls for open treatment to effect or maintain reduction. In old unreduced luxations and when the condition is congenital it may be necessary to operate to restore the bones to their normal relations. In old cases it may be necessary to resect the ulnar head when the ulna has outgrown the radius. With the end of the bone removed reduction may be accomplished and recurrence of deformity prevented by suturing the soft tissues. In recurrent cases it may be possible to shorten the lower radio-ulnar ligaments or their tension may be increased by dividing the radius about two inches from the lower end and tipping the lower fragment so that the styloid will occupy a lower level.

After-Treatment.—In recent forward or backward luxations the deformity does not tend to recur and hence no special retentive apparatus will be required aside from avoiding extreme supination or pronation according to the type of luxation. Should a tendency to recurrence be present the forearm should be immobilized in a position of rotation opposite to that in which the luxation occurred. A backward dislocation should be fixed in supination while an anterior luxation should be immobilized in pronation. Two to three weeks should be allowed for the ligaments to heal. Following operation the forearm should be immobilized for two or three weeks, or even longer in exceptional cases. If the condition is compound it should be treated according to the principles laid down in "The Treatment of Compound Fractures and Luxations," on page 789.

Prognosis.—The outlook in uncomplicated luxations of the lower end of the ulna is excellent if reduction is accomplished early. Old unreduced cases of forward or backward luxation usually show considerable disturbance in function especially in the rotary action of the forearm. In congenital luxations the loss of function is often surprisingly slight, consisting for the most part in loss of complete supination, slight weakness of the wrist and of early tiring when heavy work is performed. The same type of symptoms prevail in the backward subluxation seen in children as a result of heavy work during the years when the bones are soft. The operations recorded have been few but the results are encouraging.

CHAPTER XIX.

FRACTURES OF THE LOWER END OF THE RADIUS.

Surgical Anatomy.—The region of the wrist is compact and contains numerous tendons, nerves and vessels in close relation with the radius, ulna and carpus. The normal relations of these structures and the surface landmarks should be known before one is qualified to recognize and fully appreciate the deformities accompanying fractures of the lower end of the radius. Variations within normal limits are common in the lower ends of the radius and ulna, and the carpus is frequently the seat of pronounced anomalies. It is necessary, therefore, that the opposite wrist be examined carefully before determining the conditions present in the injured member. The styloid process of the radius normally occupies a lower level than the ulnar styloid. Nearly all fractures of the lower end of the radius are accompanied by an elevation of the radial styloid; this condition is determined by comparing the relative levels of the two styloid processes as shown in Fig. 376. The uninjured wrist is used as the standard of comparison in ascertaining the distance the radial styloid has been raised. On the anterior surface of the wrist will be noted two eminences. To the radial side is the thenar eminence; the upper margin of which is at a slightly lower level than the corresponding margin of the hypothenar eminence which is situated at the ulnar side of the wrist. When the outer side of the forearm is shortened by fracture of the radius the thenar eminence is raised according to the extent of the deformity. The outer aspect of the lower end of the radius is the only portion of the bone which is strictly subcutaneous, yet the lower half of the radius may be palpated without difficulty since there is little else than tendons interposed between the skin and the bone.

On the posterior surface of the lower expanded quadrilateral extremity of the radius are a number of vertical grooves for the accommodation of the extensor tendons passing from the forearm to the hand. At about the middle of this surface will be noted a prominent ridge which forms the outer margin of the groove for the passage of the extensor longus pollicis. The tendons of the extensor ossis metacarpi pollicis and extensor brevis pollicis pass to the outer side of the radius, obliquely across the base of the styloid process. The flexor tendons, radial artery, and median nerve pass in front of the lower end of the bone. The radial nerve as it courses down the outer side of the forearm and under the tendon of the supinator longus is sometimes injured and may

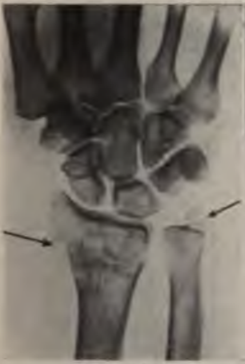
Fig. 326.

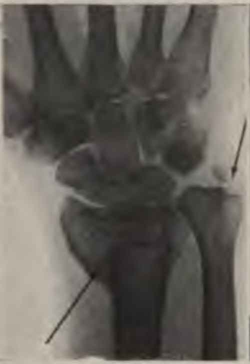
Fig. 327.

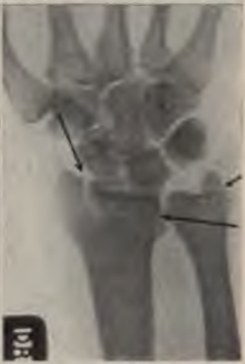
Fig. 328.

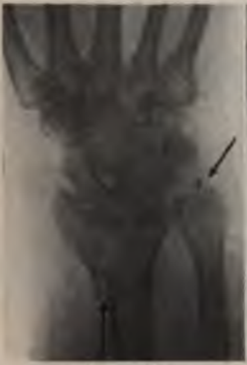
Fig. 329.

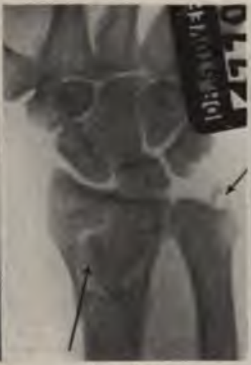
Fig. 330.

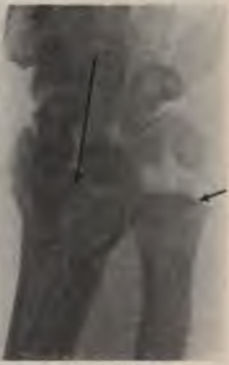
Fig. 331.

Fig. 326.—Impacted fracture of lower end of radius. Fracture of ulnar styloid.

Fig. 327.—Pronounced impaction of lower end of radius. Fracture of ulnar styloid at its base.

Fig. 328.—Fracture of ulnar side of lower end of radius and fracture of ulnar styloid.

Fig. 329.—Vertical fracture of lower end of radius and fracture of ulnar styloid.

Fig. 330.—Comminution of lower end of radius and fracture of ulnar styloid.

Fig. 331.—Extensive splitting and comminution of lower end of radius and fracture of ulnar styloid.

give rise to considerable pain during the after-treatment. The inner aspect of the lower end of the radius presents the "sigmoid cavity of the radius" for articulation with the head of the ulna; just beneath the lower margin of this surface is attached the base of the triangular fibro-cartilage, which binds the radius and ulna

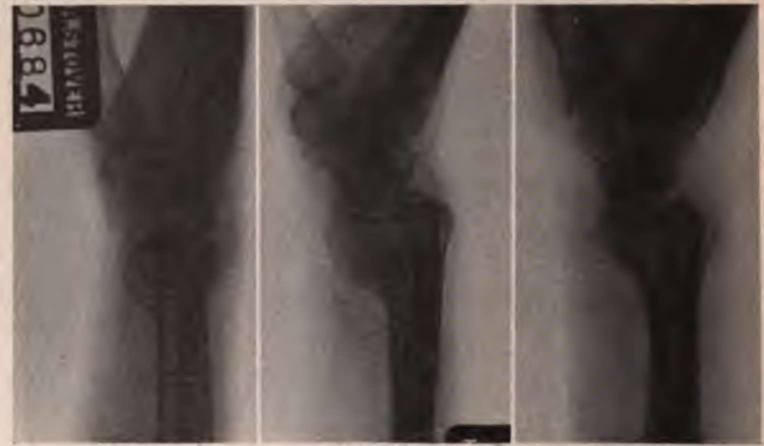

Fig. 332. Fig. 333. Fig. 334.

Figs. 332, 333 and 334.—Three good examples of Reversed Colles' fracture. The "gardener's spade" deformity is present instead of the "silver-fork" deformity.

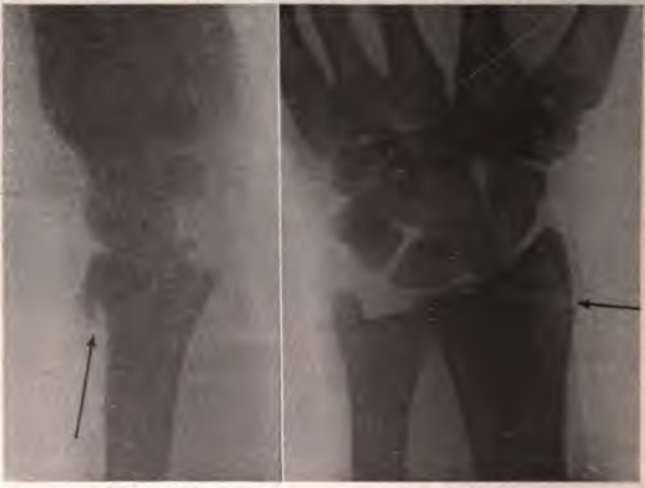

Fig. 335. Fig. 336.

Figs. 335 and 336.—Antero-posterior and lateral views of a fracture of the lower end of the radius produced by an "auto-kick."

together. With the forearm semipronated the ulnar styloid may be palpated as a prominence of bone which is continuous with the posterior subcutaneous border of the ulna. The tip of the process is on a level with the articulation of the wrist. When the forearm is carried into complete pronation the ulnar head, instead of the styloid process, presents beneath the skin. The inferior surface of the lower end of the radius articulates with the upper row of carpal bones and looks downward and slightly forward.

The internal structure of the lower end of the radius should be studied to fully appreciate the mechanism of fractures of this region. A short distance above the lower end of the bone the surface layer of compact tissue changes rapidly into the heavy tube of compact bone which forms the shaft of the radius, and it is here that fracture most often occurs. It is not uncommon to find the end of the upper fragment driven into the lower fragment, which means a more or less extensive crushing and comminution of the cancellous tissue in the lower end of the radius, and accounts to some extent for the tendency to recurrence of deformity following reduction. Thus, when the lower fragment is pulled back into position following impaction, there is a wedge-shaped space in the

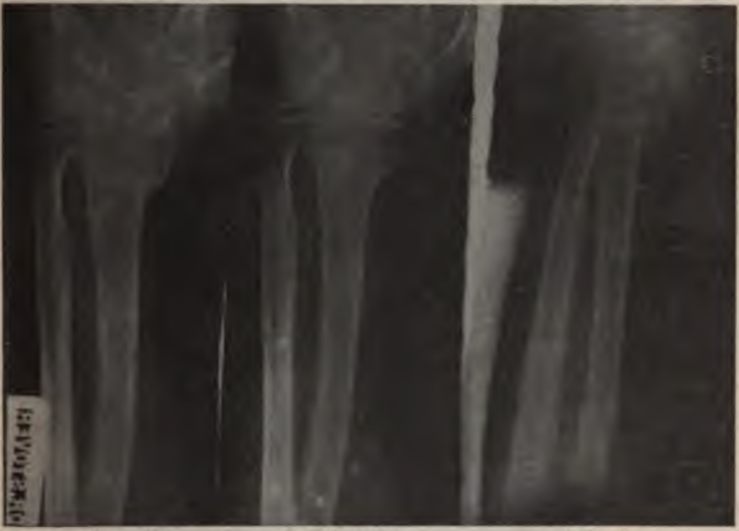

Fig. 337. Fig. 338. Fig. 339.

Figs. 337, 338 and 339.—Three views of a transverse Colles' fracture with impaction of the proximal fragment into the cancellous tissue of the distal fragment.

lower fragment corresponding to the crushed cancellous tissue, and unless the layer of compact bone on the posterior aspect of the lower fragment is firmly engaged the deformity will return when the parts are released. A consideration of the internal structure of the lower end of the radius as shown in Figs. 268 and 384 will explain this tendency to recurrence of deformity, and the necessity for overcorrecting the displacement so that the dorsal layer of compact tissue may properly engage the upper fragment.

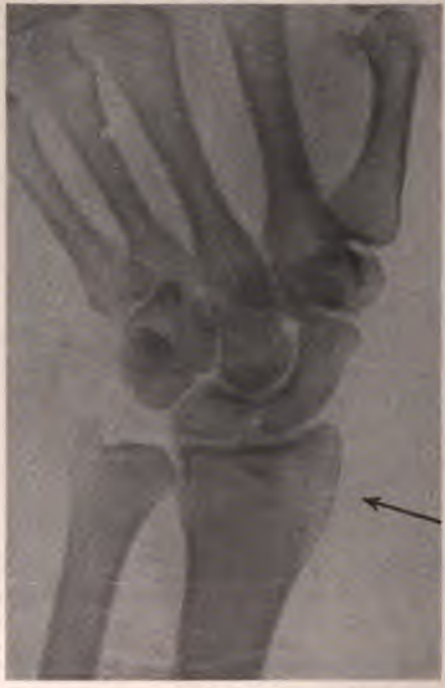

Fig. 340.—Fracture of lower end of radius produced by "auto-kick."

Fractures in this region of the skeleton show considerable variation, but the overwhelming majority corresponds, more or less closely to the type described by Colles. His original description in 1814 was of a fracture one and a half inches above the articular surface, but subsequent experience has shown that the usual break is within three-fourths of an inch of the lower end of the bone. At the present time, therefore, Colles' name is used to indicate a condition slightly different from the one originally described by him. The typical Colles' fracture is transverse or oblique, does not enter the articular surface and is accompanied by a backward

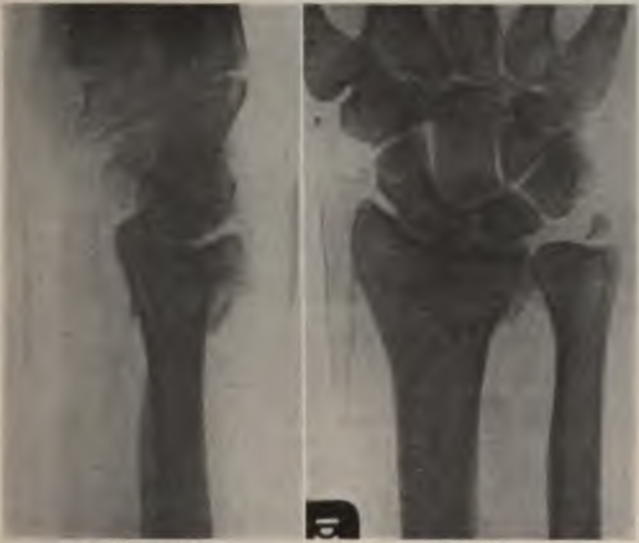

Fig. 341. Fig. 342.

Figs. 341 and 342.—Lateral and antero-posterior views of Colles' fracture with very slight deformity. Note fracture of ulnar styloid.

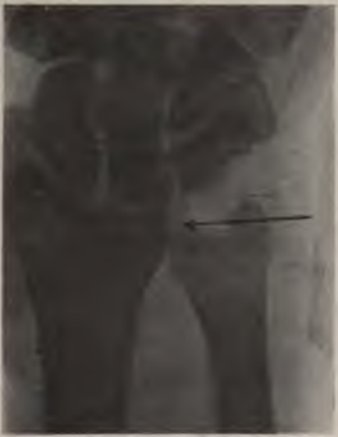

Fig. 343.—Colles' fracture with comminution of the distal fragment.

displacement of the lower fragment. This backward displacement of the distal fragment produces the typical "silver-fork" deformity which is so characteristic of Colles' fracture (see Figs. 354 to 367).

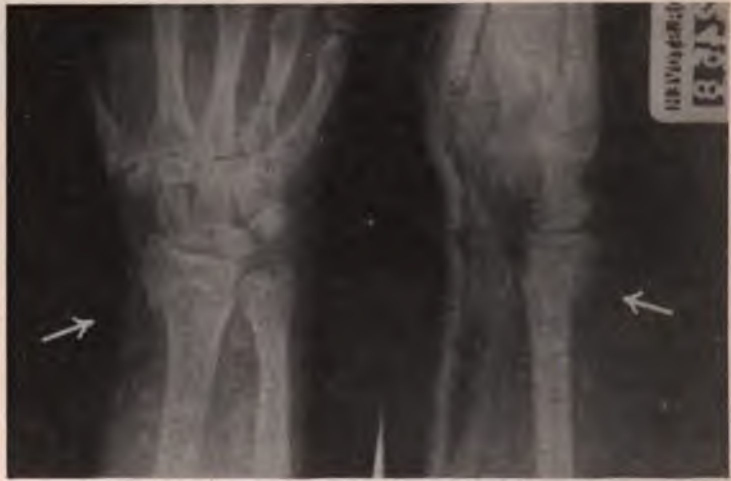

Fig. 344. Fig. 345.

Figs. 344 and 345.—Antero-posterior and lateral views of transverse Colles' fracture with impaction of upper fragment into lower, after attempt at reduction. Same case as shown in Fig. 355.

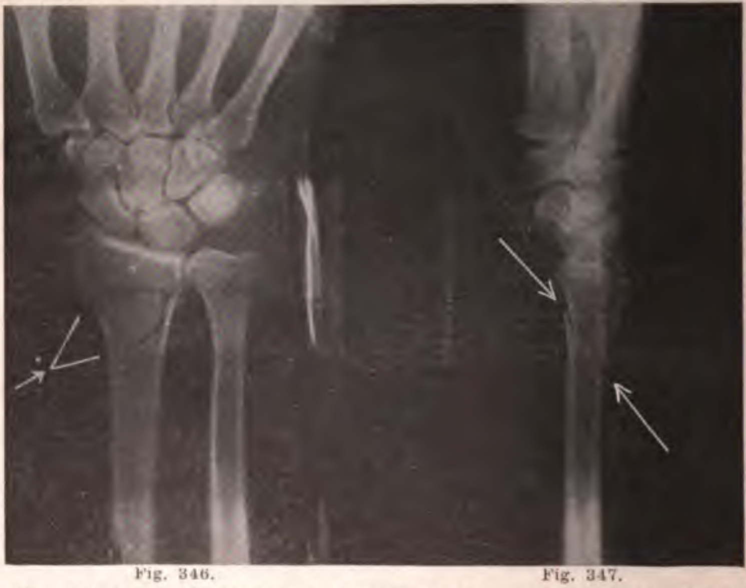

Fig. 346. Fig. 347.

Figs. 346 and 347.—Antero-posterior and lateral views of oblique Colles' fracture after reduction. Same case as shown in Figs. 366 and 367 before reduction. Note obliquity of plane of fracture and absence of crushing of cancellous tissue by impaction.

The nature of the deformity varies somewhat with the line of fracture (see "Symptoms," page 252).

The usual Colles' fracture is the result of a fall on the outstretched hand. If the fall is sustained on the palm of the hand, as is usual, the distal fragment is displaced backward and the typical Colles' fracture is the result. If impaction is present it is the cancellous tissue near the posterior surface of the lower fragment which suffers most. In rare instances the distal frag-

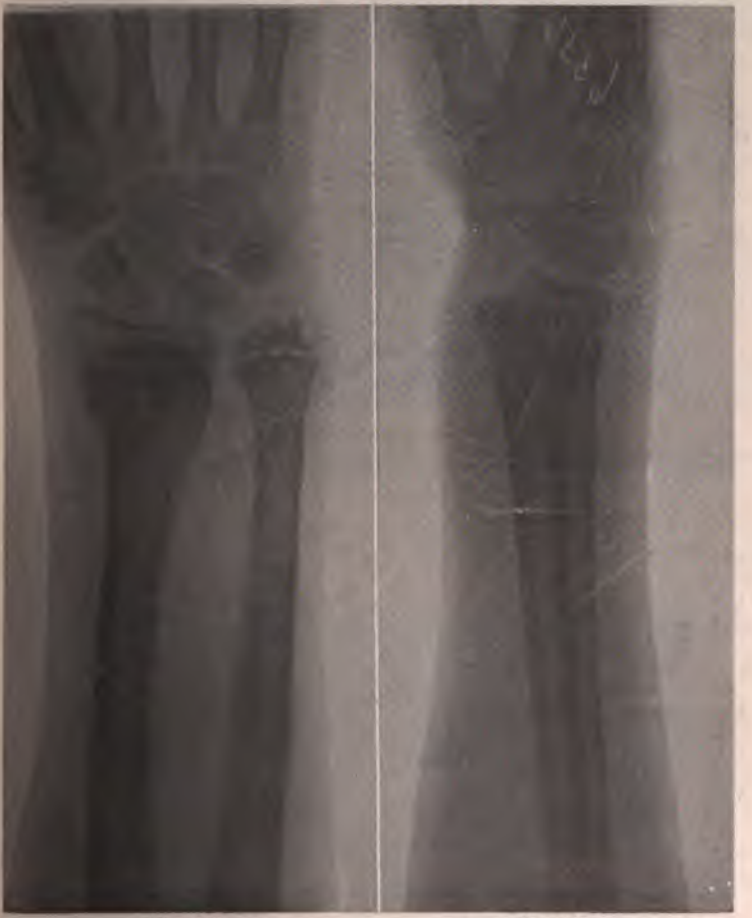

Fig. 348. Fig. 349.

Figs. 348 and 349.—Antero-posterior and lateral views of separation of lower radial epiphysis complicated by fracture of the end of the diaphysis. Same case as shown in Figs. 368, 369 and 370.

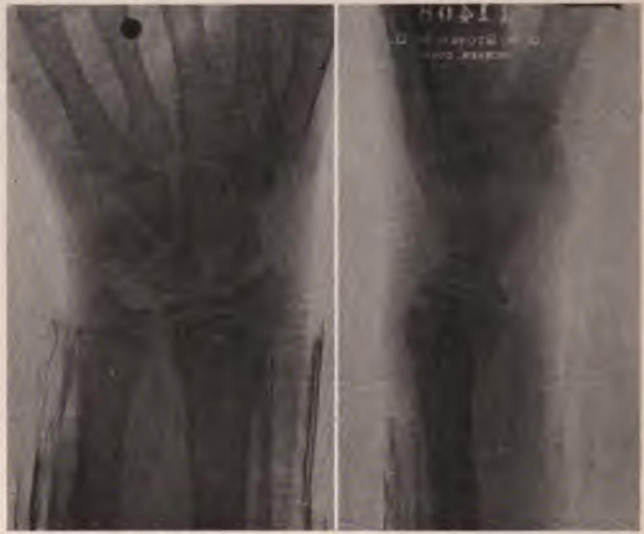

Fig. 350. Fig. 351.

Figs. 350 and 351.—Antero-posterior and lateral views of epiphyseal separation lower end of radius complicated by fracture of the lower end of the diaphysis. Defor ity corresponds to "reversed Colles'."

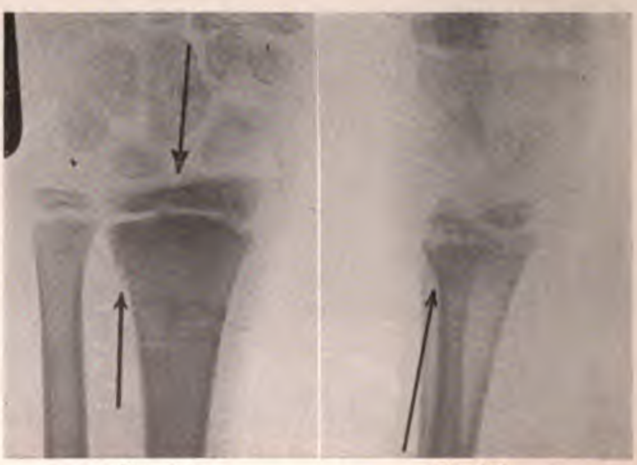

Fig. 352. Fig. 353.

Figs. 352 and 353.—Antero-posterior and lateral views of separation of the low radial epiphysis after reduction. Note the complicating fractures of both epiphysis a diaphysis.

ment may be displaced ventrally and the condition is then spoken of as a "reversed Colles' fracture." This type of deformity is usually produced when the causative trauma is received on the dorsal aspect of the hand with the wrist in flexion. Examples of reversed Colles' fracture are shown in Figs. 332 to 334.

An oblique fracture passing from the posterior surface of the lower end of the radius into the articular surface, with dorsal displacement of the fragment, is known as Barton's fracture. When the break enters the articular surface from the anterior aspect of the lower end of the radius, with ventral displacement of the fragment, the condition is spoken of as a "reversed Barton's fracture." This terminology is rather unfortunate since these two conditions are in reality luxations of the wrist complicated by fracture of the lower end of the radius. Thus Barton's fracture is a backward luxation with fracture of the posterior lip of the radius, while reversed Barton's fracture is an anterior luxation with fracture of the anterior lip of the radius. The mechanism of Barton's fracture and reversed Barton's fracture is similar to that obtaining in Colles' fracture and its reversed form.

Atypical fractures of the lower end of the radius show considerable variation: the styloid process may be broken off, a vertical fracture may pass from the shaft into the articular surface, oblique fractures may pass from either the inner or outer aspect of the bone into the articular surface, the distal fragment of a Colles' fracture may be broken into two or more pieces or may be extensively comminuted, and the same condition sometimes exists in a separated epiphysis, and finally the lower end of the bone may be so extensively comminuted that it does not resemble any of the above described fractures. In some rare instances the upper row of carpal bones have been driven upward through the articular surface of the radius so that they rested partially within the cancellous tissue of the lower end of the bone. In many of these atypical fractures the degree and nature of the deformity depend largely on the severity and direction of the causative trauma.

The lower epiphysis of the radius is ossified by a single center which makes its appearance about the end of the second year. The epiphyseal cartilage is obliterated during the twentieth year. The causes of epiphyseal separations are similar to those producing Colles' fracture, and the deformity usually consists in a backward displacement of the lower fragment. It is not uncommon to find epiphyseal separations of the lower end of the radius complicated by fracture; examples of this condition are shown in Figs. 348 to 353.

Symptoms.—The patient almost invariably gives a history of having fallen on the outstretched hand. The injury is followed immediately by severe pain and loss of function, and the sufferer presents himself for treatment and relief. The attitude is usually characteristic. He stands with the shoulders slightly forward and the forearms held horizontally across the body. The injured member is supported by the opposite hand and there is considerable

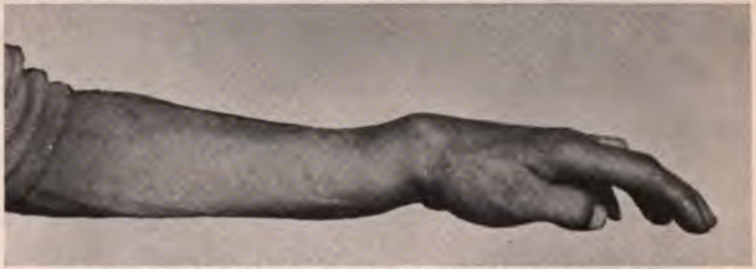

Fig. 354.—Typical Colles' fracture a few minutes following the accident. Fracture transverse and impaction present. Compare this deformity with the other Colles' fractures shown in this chapter and with the backward dislocation shown in Fig. 378.

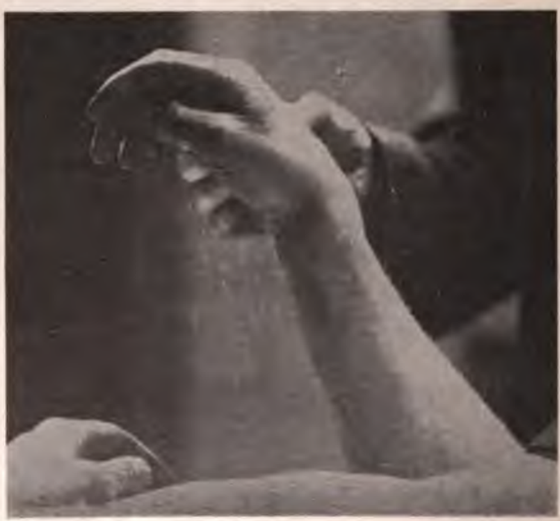

Fig. 355.—Simple Colles' fracture the result of a fall on the hand. Picture taken a short time following the accident. Appearance typical.

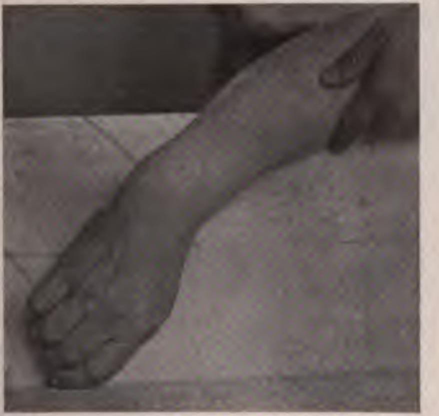

Fig. 356. An example of the radial displacement of the distal fragment sometimes seen in Colles' fracture. Note how the whole hand is displaced to the radial side.

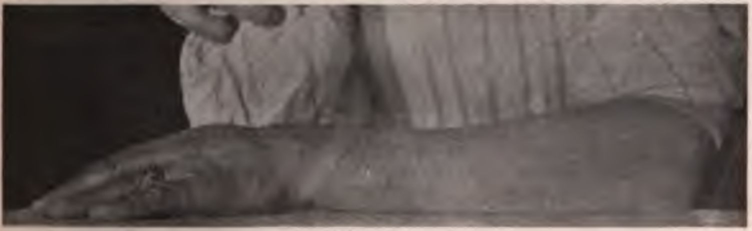

Fig. 357.

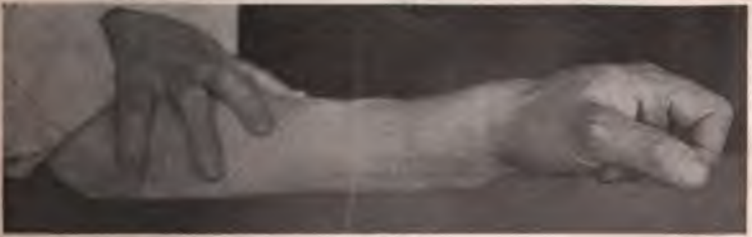

Fig. 358.

Figs. 357 and 358.—Transverse. impacted Colles' fracture a few minutes following fall on hand. This is the type of deformity illustrated in *B.*, Fig. 384. Compare this case with the deformity accompanying an oblique Colles' fracture as shown in Figs. 366 and 367. Angular deformity is here present as a result of the impaction, and the direction in which the articular surface of the radius looks has been changed. Note the prominence on the ventral and ulnar side of the wrist produced by the displaced head of the ulna.

anxiety in both attitude and gait lest the injured wrist be disturbed. The onset of swelling about the wrist is prompt and sometimes pronounced, and, unless the case is seen immediately following the accident, the deformity is to some extent masked.

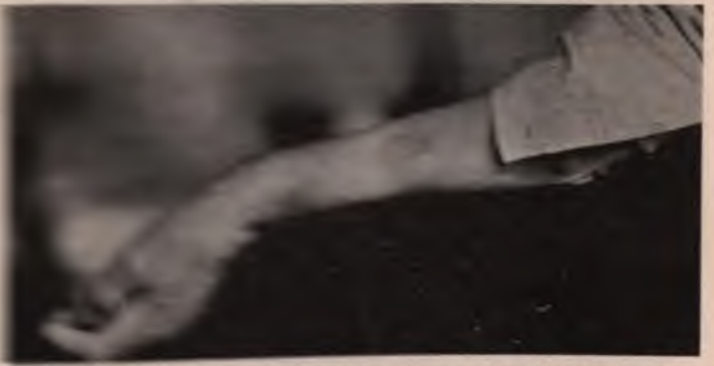

Fig. 359.—Photograph of a recent Colles' fracture showing the change in the contour of the wrist resulting from the displacement of the distal fragment. The articular surface of the radius faces downward and backward instead of downward and slightly forward, as is normal. Note the curve on the anterior surface of the wrist which is the reverse of that seen in a normal wrist in this position.

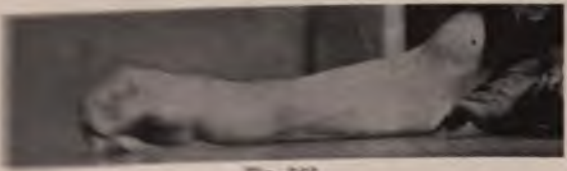

Fig. 360.

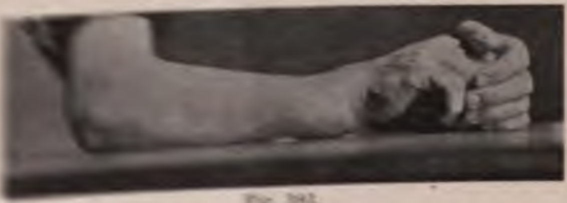

Fig. 361.

Figs. 360 and 361.—Colles' fracture a few minutes following injury. Prominence on volar surface of forearm is due to distention of the flexor tendon sheaths.

Loss of function in the hand and wrist is, as a rule, complete, and even in instances in which it might be possible for the patient to perform some acts with the injured member the pain is usually severe enough to inhibit all function.

The usual silver-fork deformity is characteristic of Colles' frac-

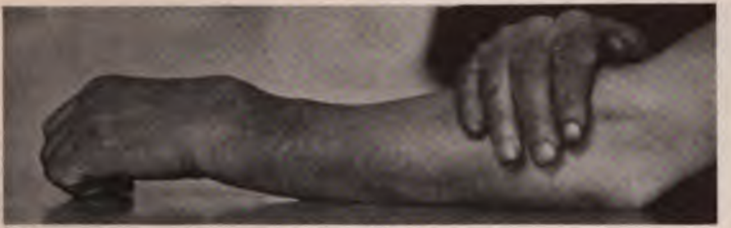

Fig. 362.

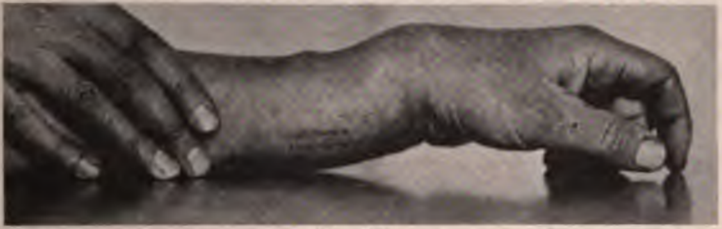

Fig. 363.

Figs. 362 and 363.—Radial and ulnar views of recent Colles' fracture. Line of fracture a little higher than usual and dorsal displacement pronounced.

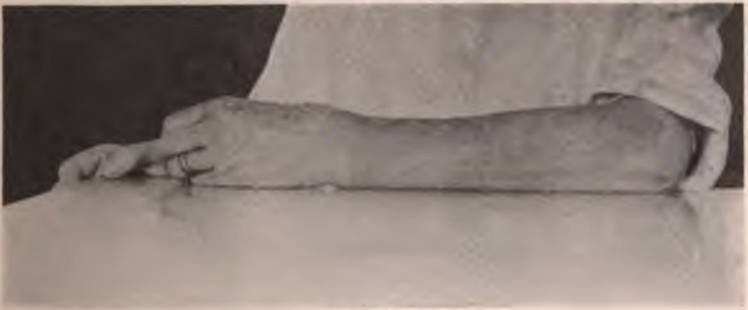

Fig. 364.

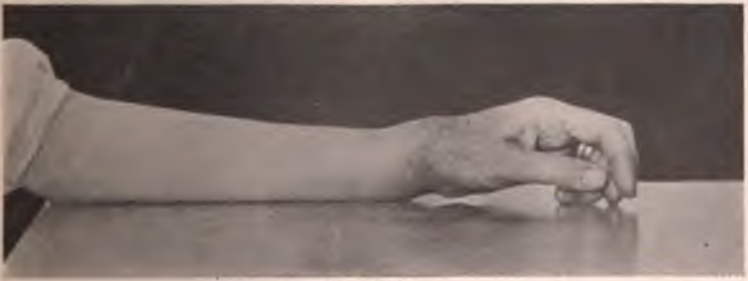

Fig. 365.

Figs. 364 and 365.—Radial and ulnar views of Colles' fracture in old woman a few minutes following the accident. Angular deformity and impaction present. Moderate displacement of lower fragment. Note prominence of ulnar head and displacement of hand to radial side.

broken up. In more than half of the cases of Colles' fracture the condition is complicated by rupture of the triangular fibro-cartilage or an equivalent avulsion of its ulnar attachment so that the head of the ulna and the lower radial fragment are separated and the wrist broadened. Fracture of the ulnar styloid, so commonly seen in Röntgenograms of Colles' fracture, is an evidence of the action of this ligament. The lower end of the ulna is, as a rule, displaced forward as well as inward, and the absence of the prominent ulnar head from the dorsum of the wrist is noticeable.

In the usual Colles' fracture the hand is inclined slightly to the radial side and the base of the thenar eminence is higher than normal. This radial displacement is sometimes pronounced, as shown in Figs. 356 and 364.

In fractures showing extensive comminution of the lower end of the radius the deformity is often not characteristic and the condition may be compound. When the fracture is produced by an auto-crank kick the displacement is often slight and the break is usually transverse. A Colles' fracture without deformity is sometimes seen, though the condition is extremely rare. Even when the deformity is slight, it is, as a rule, characteristic. In oblique Colles' fractures the ventral deformity is more pronounced and lower than in the transverse type. When the break is oblique the plane of the fracture is usually similar to that shown in Fig. 347, and the deformity is somewhat different from that seen in transverse Colles' fracture. In oblique Colles' fractures impaction, crushing of cancellous tissue and comminution are rarely present, and the rotary and angular elements in the deformity previously described are slight or absent. The lower fragment is displaced backward and slightly upward, but the axes of the two fragments are parallel, or nearly so, and the direction in which the articular surface looks remains unchanged.

In Barton's fracture the deformity is slightly lower and more abrupt than in the typical Colles' fracture. The position of the radial styloid remains unchanged and the wrist is not broadened. Crepitus is elicited during reduction and it will usually be possible to determine that the lower fragment includes only a small portion of the lower end and posterior aspect of the radius. In the reversed type of Barton's fracture the carpus is displaced forward instead of backward, and the radial styloid and posterior

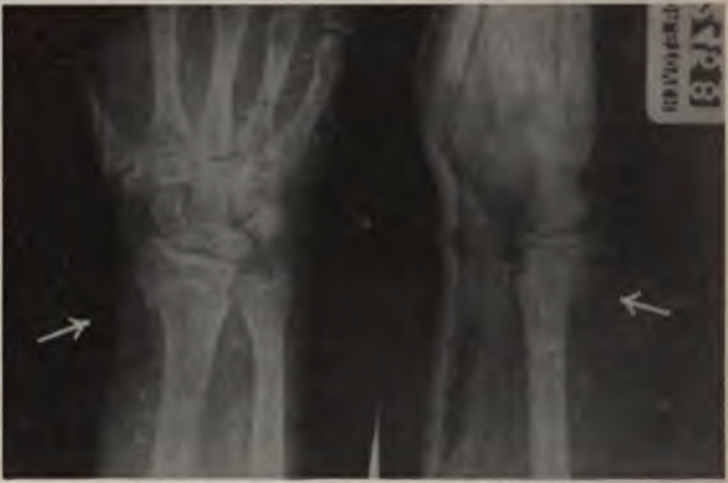

Fig. 344. Fig. 345.

Figs. 344 and 345.—Antero-posterior and lateral views of transverse Colles' fracture with impaction of upper fragment into lower, after attempt at reduction. Same case as shown in Fig. 355.

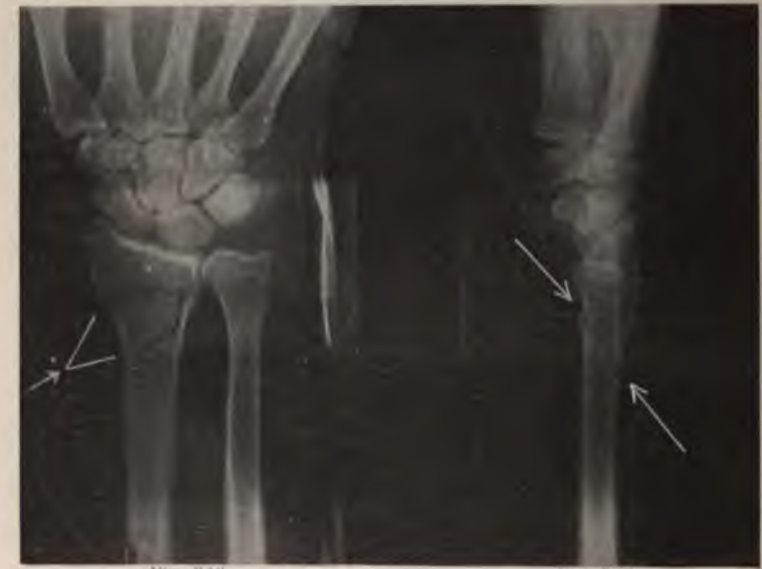

Fig. 346. Fig. 347.

Figs. 346 and 347.—Antero-posterior and lateral views of oblique Colles' fracture after reduction. Same case as shown in Figs. 366 and 367 before reduction. Note obliquity of plane of fracture and absence of crushing of cancellous tissue by impaction.

The nature of the deformity varies somewhat with the line of fracture (see "Symptoms," page 252).

The usual Colles' fracture is the result of a fall on the outstretched hand. If the fall is sustained on the palm of the hand, as is usual, the distal fragment is displaced backward and the typical Colles' fracture is the result. If impaction is present it is the cancellous tissue near the posterior surface of the lower fragment which suffers most. In rare instances the distal frag-

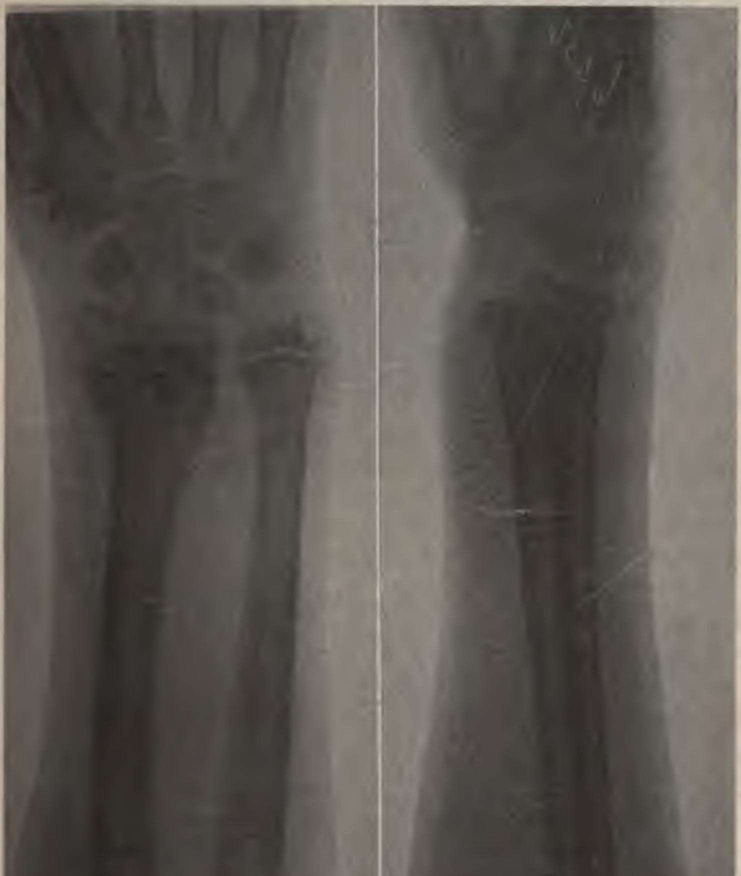

Fig. 348. Fig. 349.

Figs. 348 and 349.—Antero-posterior and lateral views of separation of lower radial epiphysis complicated by fracture of the end of the diaphysis. Same case as shown in Figs. 368, 369 and 370.

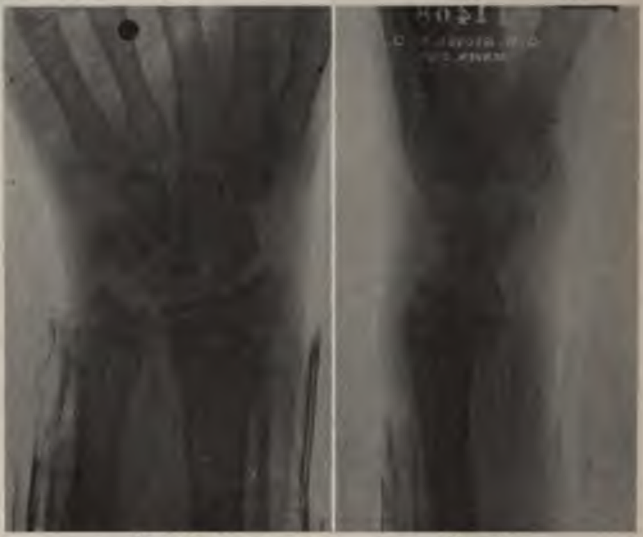

Fig. 350. Fig. 351.

Figs. 350 and 351.—Antero-posterior and lateral views of epiphyseal separation of lower end of radius complicated by fracture of the lower end of the diaphysis. Deformity corresponds to "reversed Colles'."

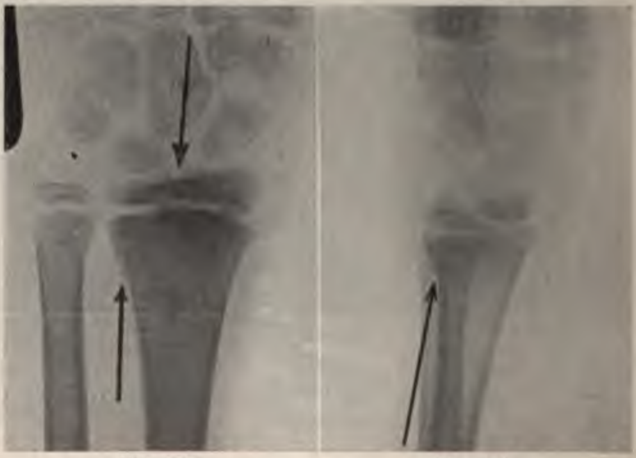

Fig. 352. Fig. 353.

Figs. 352 and 353.—Antero-posterior and lateral views of separation of the lower radial epiphysis after reduction. Note the complicating fractures of both epiphysis and diaphysis.

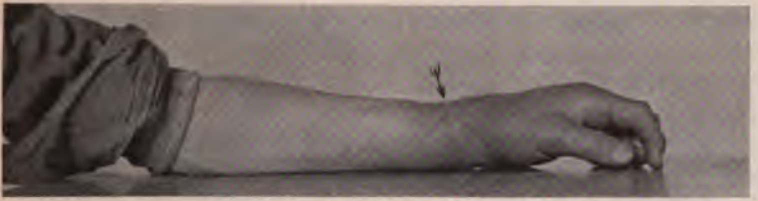

Fig. 373.—Radial view of recent Colles' fracture.

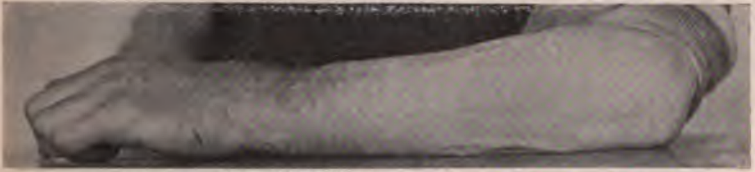

Fig. 374.—Ulnar view of same case.

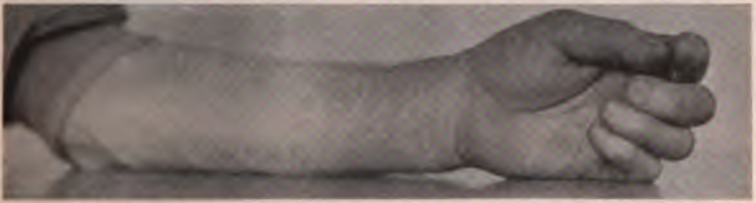

Fig. 375.—Ventral view of same case. Note prominence of ulnar head and displacement of hand to radial side.

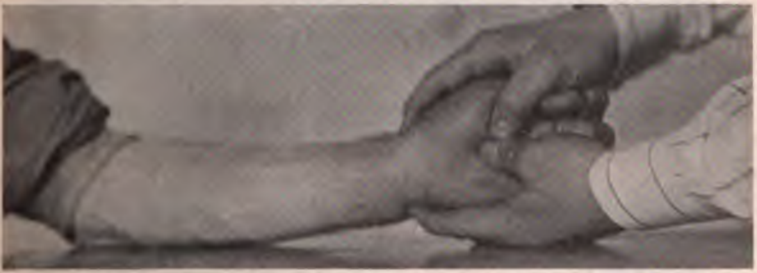

Fig. 376.—Comparing the levels of the two styloids. The radial styloid is raised though its tip is still at a lower level than the tip of the ulnar styloid.

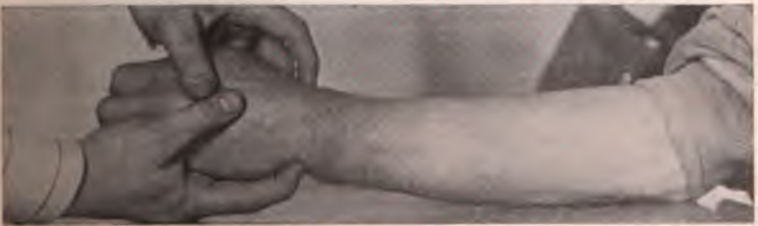

Fig. 377.—Same comparison seen from the dorsal aspect of forearm.

epiphyseal separations of the lower end of the radius complicated by fracture; examples of this condition are shown in Figs. 348 to 353.

Symptoms.—The patient almost invariably gives a history of having fallen on the outstretched hand. The injury is followed immediately by severe pain and loss of function, and the sufferer presents himself for treatment and relief. The attitude is usually characteristic. He stands with the shoulders slightly forward and the forearms held horizontally across the body. The injured member is supported by the opposite hand and there is considerable

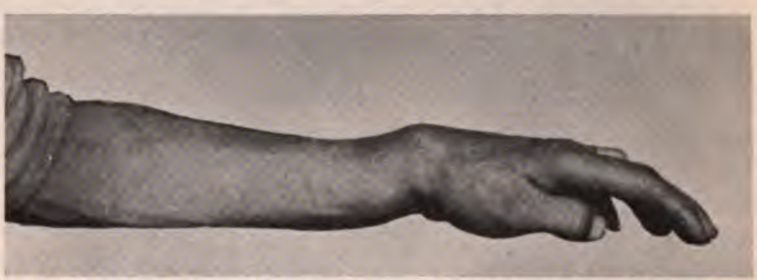

Fig. 354.—Typical Colles' fracture a few minutes following the accident. Fracture transverse and impaction present. Compare this deformity with the other Colles' fractures shown in this chapter and with the backward dislocation shown in Fig. 378.

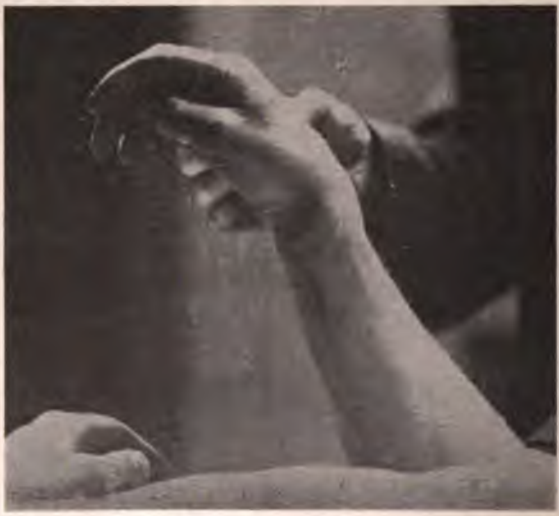

Fig. 355.—Simple Colles' fracture the result of a fall on the hand. Picture taken a short time following the accident. Appearance typical.

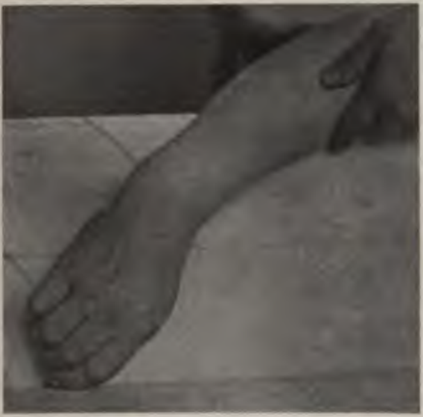

Fig. 356. An example of the radial displacement of the distal fragment sometimes seen in Colles' fracture. Note how the whole hand is displaced to the radial side.

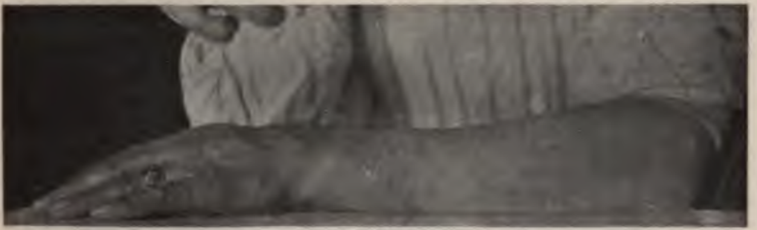

Fig. 357.

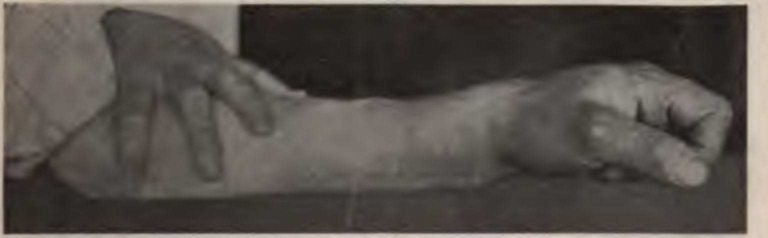

Fig. 358.

Figs. 357 and 358.—Transverse, impacted Colles' fracture a few minutes following fall on hand. This is the type of deformity illustrated in *B.*, Fig. 384. Compare this case with the deformity accompanying an oblique Colles' fracture as shown in Figs. 366 and 367. Angular deformity is here present as a result of the impaction, and the direction in which the articular surface of the radius looks has been changed. Note the prominence on the ventral and ulnar side of the wrist produced by the displaced head of the ulna.

anxiety in both attitude and gait lest the injured wrist be disturbed. The onset of swelling about the wrist is prompt and sometimes pronounced, and, unless the case is seen immediately following the accident, the deformity is to some extent masked.

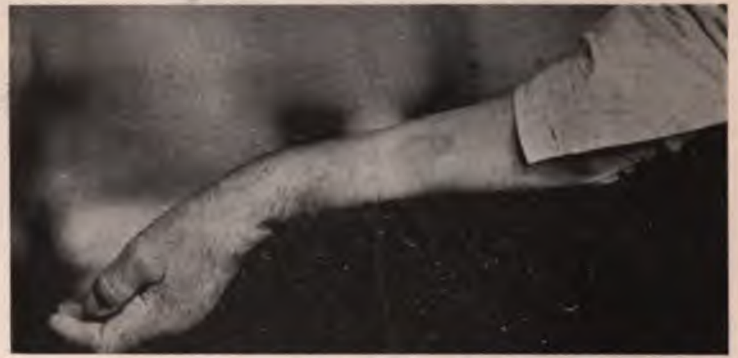

Fig. 359.—Photograph of a recent Colles' fracture showing the change in the contour of the wrist resulting from the displacement of the distal fragment. The articular surface of the radius looks downward and backward instead of downward and slightly forward as is normal. Note the curve on the anterior surface of the wrist which is less sharp than is seen in a normal wrist in this position.

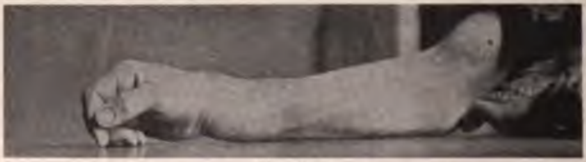

Fig. 360.

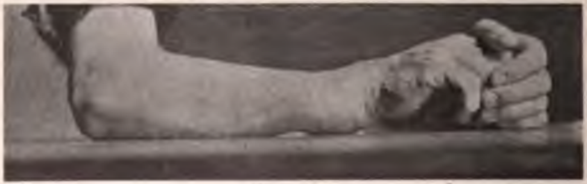

Fig. 361.

Figs. 360 and 361.—Colles' fracture a few minutes following injury. Prominence on ventral surface of forearm is due to distention of the flexor tendon sheaths.

Loss of function in the hand and wrist is, as a rule, complete, and even in instances in which it might be possible for the patient to perform some acts with the injured member the pain is usually severe enough to inhibit all function.

The usual silver-fork deformity is characteristic of Colles' frac-

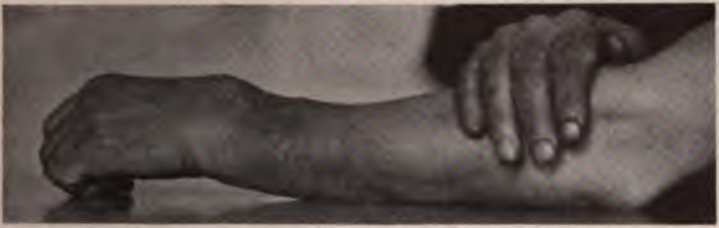

Fig. 362.

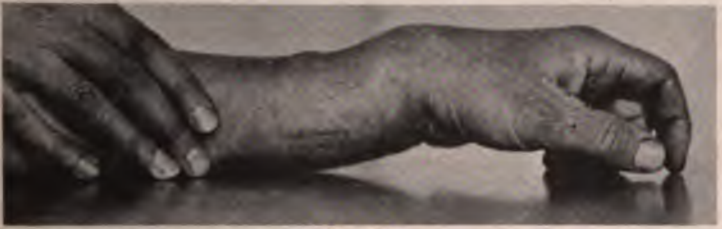

Fig. 363.

Figs. 362 and 363.—Radial and ulnar views of recent Colles' fracture. Line of fracture a little higher than usual and dorsal displacement pronounced.

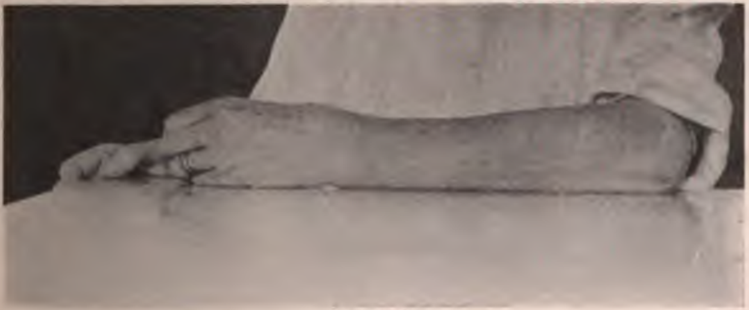

Fig. 364.

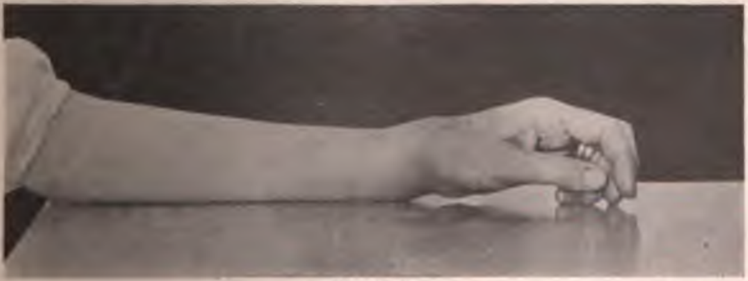

Fig. 365.

Figs. 364 and 365.—Radial and ulnar views of Colles' fracture in old woman a few minutes following the accident. Angular deformity and impaction present. Moderate displacement of lower fragment. Note prominence of ulnar head and displacement of hand to radial side.

ture and can best be appreciated by a study of the accompanying photographs. No amount of text will convey an idea of the nature of this deformity as readily as these illustrations. The radial styloid is usually raised above its normal level, though in many instances the displacement is not marked enough to bring the tip of the process above the level of the end of the ulnar styloid. (See Figs. 376 and 377.) In a transverse Colles' fracture with impaction there is generally rotation and angular deformity as well as backward displacement of the lower fragment. Under these circumstances it will be noted that the radial side of the wrist is displaced further backward than the ulnar side, and that the axis of the lower fragment is not parallel with the axis of the shaft. Crepitus is easily detected in unimpacted cases. In impacted cases crepitus will be absent until the impaction has been

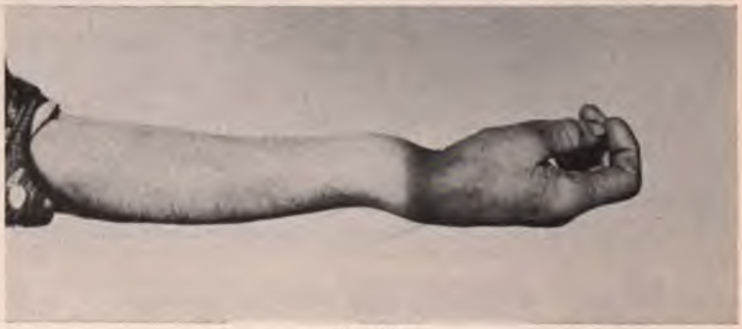

Fig. 366.

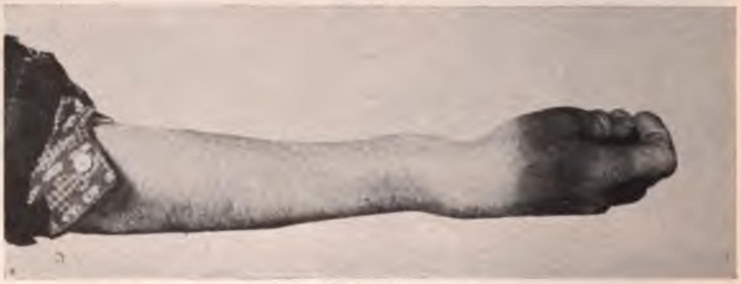

Fig. 367.

Figs. 366 and 367.—Oblique Colles' fracture a few minutes following injury. Forearm somewhat resembles fracture of both bones of the forearm though palpation discloses an intact ulna. The obliquity of the fracture is shown by the deformity. Note how low and pronounced the anterior deformity is as compared with the dorsal outline. Compare this deformity with the cases of transverse Colles' fracture previously shown and examine the accompanying Röntgenograms. X-ray of this case is shown in Figs. 346 and 347.

broken up. In more than half of the cases of Colles' fracture the condition is complicated by rupture of the triangular fibro-cartilage or an equivalent avulsion of its ulnar attachment so that the head of the ulna and the lower radial fragment are separated and the wrist broadened. Fracture of the ulnar styloid, so commonly seen in Röntgenograms of Colles' fracture, is an evidence of the action of this ligament. The lower end of the ulna is, as a rule, displaced forward as well as inward, and the absence of the prominent ulnar head from the dorsum of the wrist is noticeable.

In the usual Colles' fracture the hand is inclined slightly to the radial side and the base of the thenar eminence is higher than normal. This radial displacement is sometimes pronounced, as shown in Figs. 356 and 364.

In fractures showing extensive comminution of the lower end of the radius the deformity is often not characteristic and the condition may be compound. When the fracture is produced by an auto-crank kick the displacement is often slight and the break is usually transverse. A Colles' fracture without deformity is sometimes seen, though the condition is extremely rare. Even when the deformity is slight, it is, as a rule, characteristic. In oblique Colles' fractures the ventral deformity is more pronounced and lower than in the transverse type. When the break is oblique the plane of the fracture is usually similar to that shown in Fig. 347, and the deformity is somewhat different from that seen in transverse Colles' fracture. In oblique Colles' fractures impaction, crushing of cancellous tissue and comminution are rarely present, and the rotary and angular elements in the deformity previously described are slight or absent. The lower fragment is displaced backward and slightly upward, but the axes of the two fragments are parallel, or nearly so, and the direction in which the articular surface looks remains unchanged.

In Barton's fracture the deformity is slightly lower and more abrupt than in the typical Colles' fracture. The position of the radial styloid remains unchanged and the wrist is not broadened. Crepitus is elicited during reduction and it will usually be possible to determine that the lower fragment includes only a small portion of the lower end and posterior aspect of the radius. In the reversed type of Barton's fracture the carpus is displaced forward instead of backward, and the radial styloid and posterior aspect of the lower extremity of the bone are found to be intact and unduly prominent when palpated.

The symptoms of atypical fractures of the lower end of the radius vary with the position of the fracture and the direction of the displacement. Vertical fractures of the lower end of this bone are not accompanied by silver-fork deformity though they are almost invariably productive of considerable broadening of the wrist. An oblique fracture passing from the inner border of the bone to the articular surface is often quite difficult to recognize without the aid of the X-ray. An example of this type of fracture is shown in Fig. 329. In severe crushing injuries of the lower end of the radius the condition may be flail-like and quite apparent on the most superficial examination.

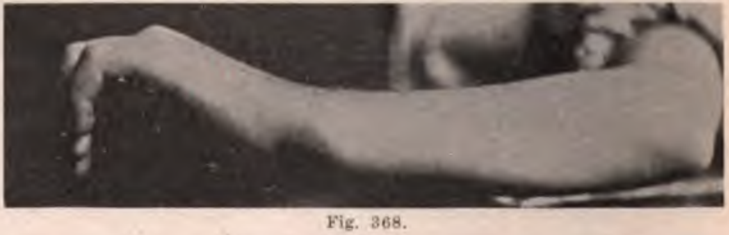

Fig. 368.

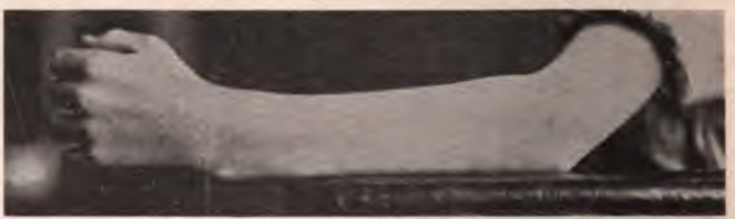

Fig. 369.

Figs. 368 and 369.—Two views of an old epiphyseal separation complicated by fracture of the posterior aspect of the diaphysis. X-ray of this case shown in Figs. 348 and 349. Note the low ventral deformity caused by the lower end of the upper fragment and the lateral prominence of the lower end of the ulna. Deformity resembles Barton's fracture. Case first seen by author six weeks following accident.

The deformity accompanying epiphyseal separations is similar to that seen in the ordinary Colles' fracture. It is, however, slightly lower and more abrupt in outline and not accompanied by true crepitus unless complicated by fracture. Epiphyseal separations are often complicated by fracture as shown in Figs. 348 to 353. When the posterior aspect of the diaphysis is broken off and displaced with the epiphysis the deformity closely resembles that seen in oblique Colles' fracture. The dorsal deformity is slight while the ventral deformity is pronounced and low. The deformity accompanying an uncomplicated epiphyseal separation is shown in Fig. 371.

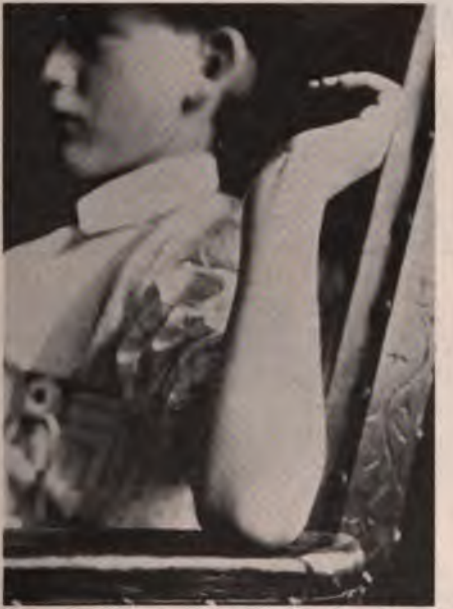

Fig. 370.—Another view of case shown in Figs. 368 and 369.

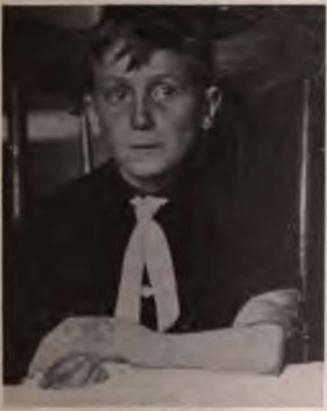

Fig. 371.

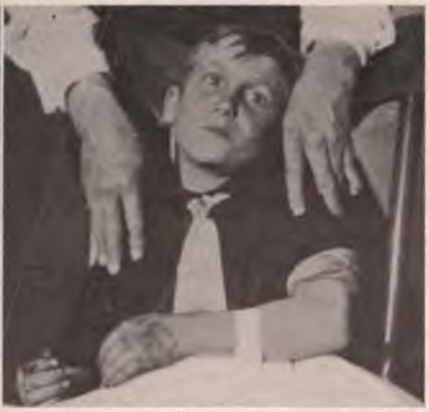

Fig. 372.

Fig. 371.—Uncomplicated epiphyseal separation of lower end of radius.

Fig. 372.—Same case immediately following reduction. Forearm partly secured to ventral splint.

Diagnosis.—Colles' fracture is the most common break occurring in the lower end of the radius and the symptoms are, as a rule, so characteristic that there should be little difficulty in recognizing the injury. The history of the case, the typical silver-fork deformity, the elevation of the radial styloid, and the broadening of the wrist are symptoms which should be recognized at a glance. In typical cases the diagnosis of Colles' fracture is established without difficulty but the exact nature and position of the break and the presence of complicating fractures of the lower end of the ulna or of the carpus are often learned only when the wrist is submitted to the X-ray. Many of the salient features of the fracture may be determined by the nature of the deformity (see "Symptoms," page 252), and the surgeon should gather these data during the examination. Prompt reduction is indicated and it is seldom advisable to await the returns of an X-ray examination before correcting the displacement. It is apparent, therefore, that no detail in the physical examination should be slighted which will aid in disclosing the nature of the fracture or the character of the displacement. When a fracture in this region is suspected the surgeon should compare the injured parts with the opposite wrist. The transverse diameters of the two wrists should be carefully compared.

The possibility of associated lesions must be kept in mind while examining fractures of the lower end of the radius. Fractures of both bones of the forearm near the wrist, luxations of the lower end of the ulna, dislocations of the wrist and fractures or luxations of the carpal bones are conditions which must be differentiated from fractures of the radius, and recognized as complications when they exist. When both bones of the forearm are fractured near the wrist, crepitus and abnormal mobility of the ulnar head may be detected on manipulation. It is often difficult to recognize complicating fracture of the ulnar styloid without the aid of the X-ray. Dislocations of the wrist are extremely rare and are seldom mistaken for Colles' fracture. Colles' fracture, however, is not infrequently wrongly diagnosticated as a dislocation. There should be no excuse for this mistake if the two deformities are compared. (See photographic comparison of the two conditions as shown in Figs. 378 and 379.) The deformity in dislocation is much lower and more abrupt in outline and the extensor tendons stand out prominently as they pass from the forearm to

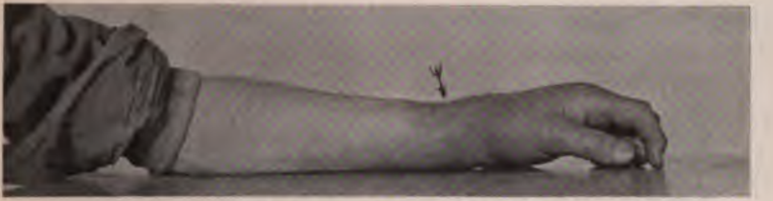

Fig. 373.—Radial view of recent Colles' fracture.

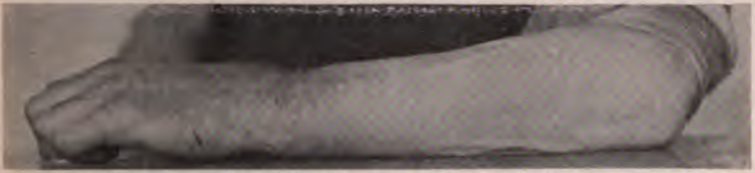

Fig. 374.—Ulnar view of same case.

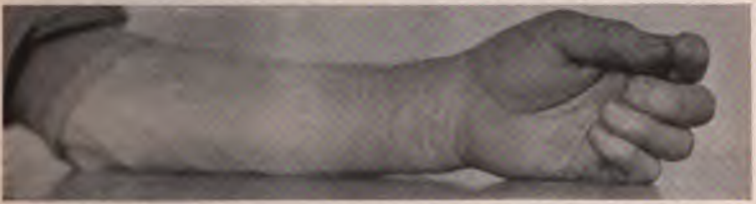

Fig. 375.—Ventral view of same case. Note prominence of ulnar head and displacement of hand to radial side.

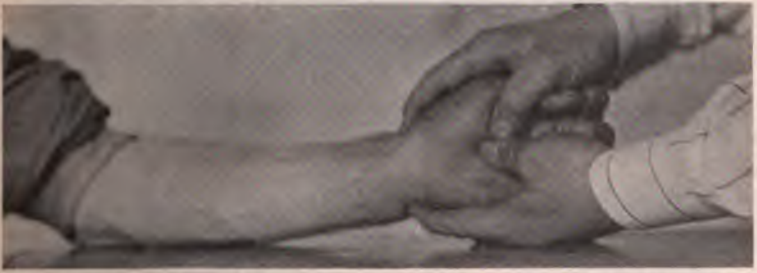

Fig. 376.—Comparing the levels of the two styloids. The radial styloid is raised though its tip is still at a lower level than the tip of the ulnar styloid.

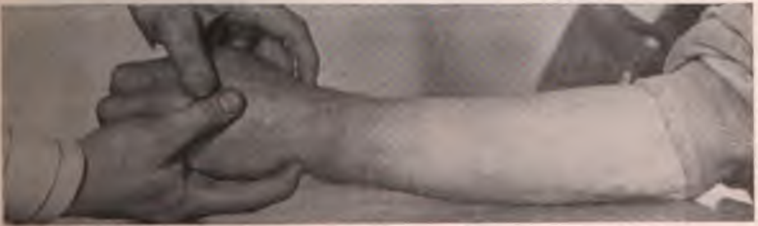

Fig. 377.—Same comparison seen from the dorsal aspect of forearm.

the hand. Neither the anterior nor the posterior type of luxation of the ulnar head occurs as a complication of Colles' fracture and as isolated injuries the symptoms of these two dislocations are too characteristic and pronounced to require differentiation. Inward luxation of the ulnar head, however, is a very common complication of Colles' fracture and is frequently overlooked. Broadening of the wrist, with inward and forward slumping of the ulnar head, is indicative of this complication. On palpation, the lower end of the ulna is found less firmly attached to the radius than normal. It may be possible to palpate the fractured styloid. It is usually not difficult to differentiate fractures and luxations of the carpus from Colles' fracture, yet lesions of the carpus accompanying Colles' fracture are not very uncommon and may be overlooked. The carpus should be examined for deformity and crepitus. If doubt exists after the wrist is thoroughly examined it is advisable to resort to the X-ray. Thus the diagnosis is established, the details of the lesion or lesions are disclosed and the parts will have been subjected to the least possible manipulation and trauma. When, on the other hand, the presence of fracture is apparent on examination and the deformity has been immediately corrected, a Röntgenogram should be made to determine the completeness of reduction, to verify the diagnosis and to exclude associated lesions of adjoining bones.

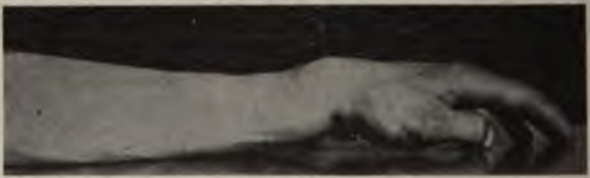

Fig. 378.

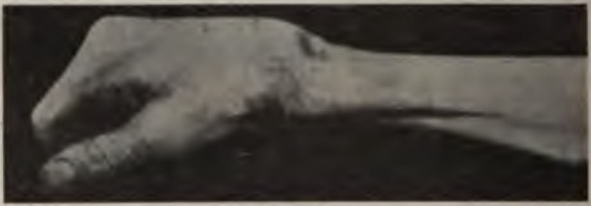

Fig. 379.

Figs. 378 and 379.—Photographic comparison of Colles' fracture and backward dislocation of wrist. The dislocation (lower picture) shows a much more abrupt deformity, except where the tendons cross the articulation and the ventral deformity is much lower.

The differentiation of Colles' fracture from simple sprain of the wrist is at times more confusing than would at first appear. Swelling of the parts and distention of the synovial sheaths following a sprain may simulate, to some extent, the deformity of Colles' fracture. Unless one is familiar with the condition and a careful examination is made, a sprain may be mistaken for a fracture, or

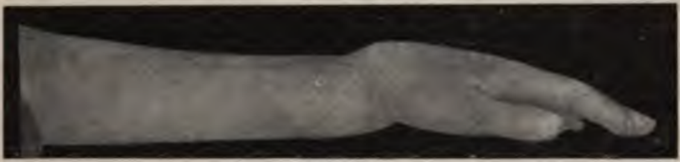

Fig. 380.

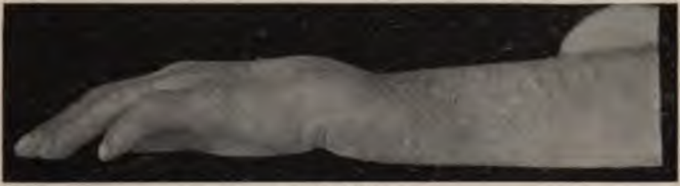

Fig. 381.

Figs. 380 and 381.—Radial and ulnar views of Colles' fracture just before reduction. (See Figs. 382 and 383.)

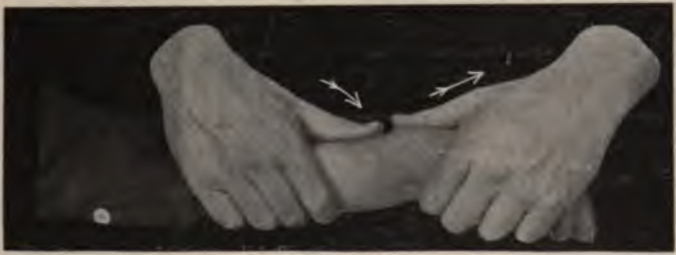

Fig. 382.

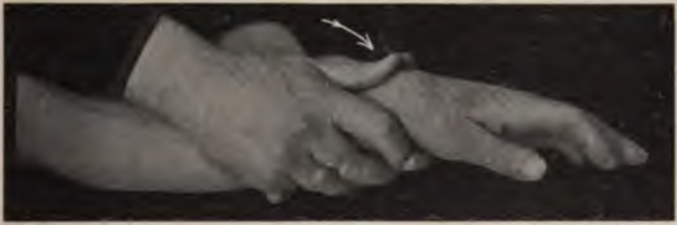

Fig. 383.

Figs. 382 and 383.—Two methods of grasping the wrist in reducing Colles' fracture. The arrows indicate the lines of force employed.

vice versa. The soft crepitation of a synovitis should not be mistaken for the true crepitus accompanying fracture. Synovial crepitation is limited to the course of the tendons and is not produced by stress on the lower end of the radius.

Treatment.—Reduction should be effected at the earliest possible moment. The sooner the deformity is corrected the less pronounced will be the subsequent traumatic reaction. Reduction is best accomplished under anesthesia. In many cases a satisfactory adjustment of the fragment can be accomplished without this aid, yet with the patient unconscious and free from pain the surgeon is better enabled to obtain an accurate reposition of the fragment. If the fracture is impacted considerable force may be needed to free the lower fragment so that it may be replaced. In oblique Colles' fracture the lower fragment can, as a rule, be slid

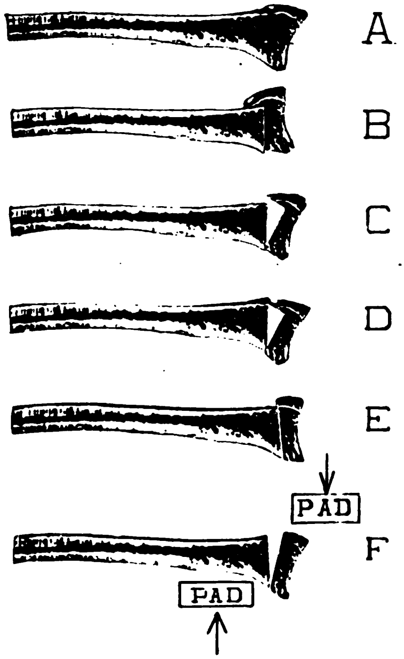

Fig. 384.—Shows the principles to be followed in reducing the usual transverse impacted Colles' fracture. *A*. Section of normal radius. *B*. Transverse impacted Colles' of common type. *C*. shows lower fragment forced back into position. Note wedre-shaped space, the result of crushed cancellous tissue. If the fragment is released in this position deformity will recur since the posterior layer of compact tissue is not engaged. *D*. shows distal fragment forced forward, thus obtaining an engagement which prevents recurrence of deformity. *E*. represents a form of fracture in which the posterior cortical layer of the distal fragment is broken up. *F*. shows the use of pads on the splints to maintain reduction when the fracture is of the type shown in *E*.

back into position but the deformity is likely to recur if the fragments are not firmly engaged following reduction. For this reason the fractured surfaces should be forced together after the fragment has been replaced. When the fracture is transverse and there is impaction and crushing of cancellous tissue, reduction requires a somewhat different manipulation. In this form of fracture the fragments must be separated by traction and counter-traction to pull the lower end of the upper fragment out of the lower fragment. When this has been accomplished the lower fragment is pulled downward and forward and the deformity slightly over-corrected. In this way the layer of compact tissue on the posterior surface of the lower fragment is engaged against the corresponding layer in the upper fragment and redisplacement is prevented. If this is not accomplished the deformity will recur since the lower end of the upper fragment will drop back into the space in the lower fragment corresponding to the crushed cancellous tissue. The accompanying diagrams (Fig. 384) illustrate the manner in which deformity recurs and the necessity for slightly over-correcting the displacement. Manipulations such as shown in Figs. 382 and 383 are recommended in correcting the displacement but the most important requisite for proper reduction is a clear understanding on the part of the surgeon concerning the nature of the break and the relative positions of the fragments.

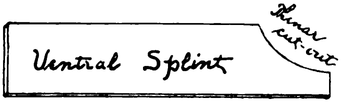

Fig. 385.

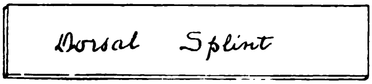

Fig. 386.

Figs. 385 and 386.—Diagrams of splints used in the treatment of fractures of the forearm. The ventral splint is cut out to avoid pressure on the thenar eminence. (See Figs. 307 to 312.)

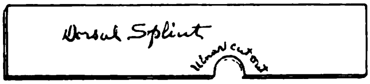

Fig. 387.—Shows a dorsal splint, cut-out opposite the head of the ulna. This is rarely needed if a heavy enough layer of padding is used.

The grip shown in Fig. 383 usually works well in the oblique type of Colles' fracture while the one shown in Fig. 382 is most efficient when the break is transverse and impaction exists. If the lower radio-ulnar articulation remains intact reduction can sometimes be effected by strong ulnar flexion of the wrist. By this method the radio-ulnar articulation is used as a fulcrum in forcing the lower radial fragment back into position. Care should be exercised, however, not to place more strain on the articulation than it will stand as otherwise it may be broken up, thus increasing the damage instead of correcting the deformity. After the displacement of the radial fracture has been corrected lateral pressure should be exerted on the lower end of the ulna to force the ulnar head home against the sigmoid cavity of the radius; thus correcting the lateral and forward displacement of the ulna.

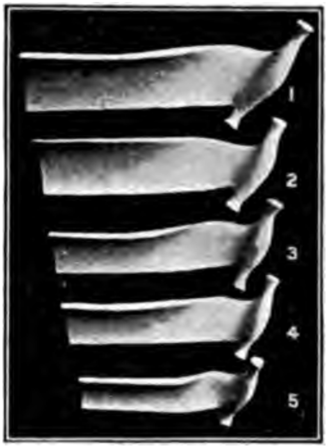

Fig. 388. —The Walker splint. Made in "rights" and "lefts" and in five sizes for the treatment of Colles' fracture.

Numerous splints have been devised to prevent recurrence of deformity and they are of some advantage, though their value has been greatly exaggerated. Special padding and splints of special design should never be used with the idea of actively correcting deformity. The displacement should be overcome as fully as possible at the time of reduction and the most that should be attempted in fixation of the parts is to prevent the recurrence of the deformity. The various types of dressing which have been employed in the fixation of Colles' fracture are too numerous to mention. The most important element in the treatment of these cases is to secure an accurate reduction and firm engagement of the fragments, and to then protect the parts from strains which might disturb the fragments. The nature of the fixation employed will depend on the tendency to recurrence of deformity and the age and temperament of the patient. An adult may in most cases be depended upon to avoid disturbing the parts during the after-treatment and to follow the instructions given by the surgeon. On the other hand an active child cannot be trusted and the wrist should be so firmly dressed that the parts are not likely to be accidentally disturbed.

When therefore a solid engagement can be obtained in a dependable adult the wrist may be encircled with a strip of adhesive plaster and the forearm carried in a sling. The hand should not be supported by the sling but is allowed to hang dependent from the wrist in a position of ulnar flexion. Excellent results can be obtained in this way, provided a solid engagement of the fragments has been secured and the patient follows directions and does not disturb the parts. If a short, properly padded dorsal splint is secured in position with a circular strip of adhesive plaster the immobilization will be found more secure than that obtained by the encircling strip of adhesive alone. When the short dorsal splint is employed appropriate padding should be placed between the adhesive and the ventral surface of the wrist. In instances in which there has been much comminution and the tendency to recurrence of deformity cannot be overcome during reduction this method is entirely too insecure and should not be employed. Under

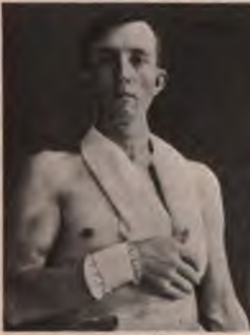
Fig. 389.

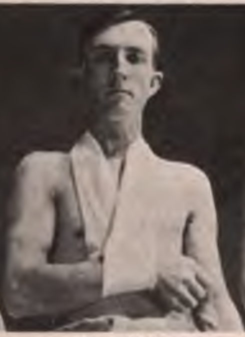
Fig. 390.

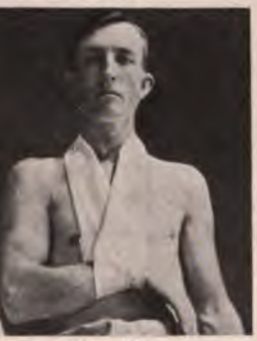
Fig. 391.

Fig. 389.—Short splints applied to wrist and held in position by circular strap of adhesive.

Fig. 390.—Shows proper position of wrist and hand. Wrist is carried in ulnar flexion.

Fig. 391.—Shows improper method of carrying wrist and hand. Forearm pronated and wrist flexed.

these circumstances the anterior and posterior splints such as used in the treatment of fractures of the forearm will, in most cases, serve the purpose better. Heavy padding of the posterior splint below the plane of fracture and of the anterior splint above the break will tend to prevent the return of the silver-fork deformity. The best material for this special padding is saddler's felt which may be obtained from any harness shop. It is elastic, holds its shape well and may be cut into pads of desired proportions. The splints should be a little broader than the forearm in its thickest part and should be loosely enough applied to avoid constriction. The forearm should not be bandaged before the splints are placed in position. The padding is never used with the expectation of actively forcing the fragments back into place but only for the purpose of preventing redisplacement. One splint, usually the anterior, is secured in place by strips of adhesive. The opposite splint is then applied and may be removed separately during the after-treatment without depriving the fracture of the support offered by the opposite splint. (See Figs. 307 to 312.) In this way the anterior splint supports the forearm and wrist while the surgeon is inspecting the parts and readjusting the dressing. It is of paramount importance that free circulation be present after the dressings are in place. During the first few days following the injury due allowance should be made for the swelling which comes with traumatic reaction. Constriction may be readily detected by examining the nails. The dangers of too tight bandaging and strangulation of the forearm have already been mentioned under "Fractures of Bones of the Forearm." The Bond splint and others of the same type which maintain the wrist in a position of ulnar flexion are of service in some cases but their value has been greatly overestimated. It has been customary for years to consider the position of the hand as exerting great influence on the recurrence of deformity. As a matter of fact there are a few conditions in which the position of the hand affects the position of the fragment, but in nearly all fractures in this region the prime requisite in avoiding the recurrence of deformity is the proper reduction of the deformity and firm engagement of the fragments. If the lower radio-ulnar articulation remains intact ulnar flexion will tend to hold the lower radial fragment in reduction, but if the articulation has been broken up, this position will only increase the displacement of the ulnar head. Comminution of the lower end of the radius, crushing of the cancellous tissue in this region and obliquity in the plane of fracture are the most common causes of recurrence of deformity following proper reduction, and the position of the hand during the after-treatment has little influence in maintaining reduction when these conditions exist. Flexion of the wrist places the extensor tendons on the stretch and they are thus supposed to exert a splinting action on the fragments. Ulnar flexion throws more strain on the ulna and relieves the radius, to some extent, of the shortening effect of the muscles of the forearm. It is questionable, however, if either of these positions makes enough difference to be of practical importance in the treatment of Colles' fracture. Extensive comminution of the lower end of the radius renders the fragments difficult to maintain in good reduction and it is here that ulnar flexion will be found of most value, provided the lower radio-ulnar articulation has not been broken up.

The reduction of Barton's fracture involves the same principles as already described in correcting the deformity of Colles' fracture. In atypical fractures of the lower end of the radius the surgeon must be guided by the nature of the fracture and the character of the displacement. If the type of the fracture is fully appreciated the surgeon will be better able to correct the deformity and hence the value of the X-ray, especially in instances in which difficulty is experienced in correcting the displacement. Occasionally cases are encountered in which reduction cannot be accomplished without resorting to open incision. The local use of the ice bag during the first twenty-four to forty-eight hours will be found of great service in controlling the traumatic reaction, especially in cases in which the causative trauma has been severe.

Operative Treatment.—Operation is sometimes indicated when a satisfactory reduction cannot be otherwise obtained. A small fragment of bone may become interposed between the fractured surfaces and require removal before the deformity can be corrected. Direct reposition of the fragments through the incision will be all that is required in most cases.

The common fracture of the lower end of the radius is best approached through a longitudinal incision on the outer side of the wrist. This incision exposes the radial artery and nerve and the extensors of the thumb. Under cover of the posterior lip of the wound will be found the radial extensors of the carpus. The course of the radial artery is sometimes anomalous, winding around the lower fourth of the radius instead of passing through the anatomical snuff-box. This condition may be recognized by palpating the artery even before the incision is made. Oblique Colles' fracture and some of the atypical breaks seen in the lower end of the radius may need some form of internal fixation to prevent recurrence of deformity. The placing of this material will depend entirely on the nature of the fracture and the character of the displacement. In oblique fractures which cannot otherwise be maintained in reduction a small loop of wire passing through the fragments will often accomplish all that is desired. In instances of pronounced radial displacement of the lower fragment a satisfactory fixation may be obtained in some cases by nailing the lower fragment to the upper as shown in Fig. 393. Epiphyseal separations seldom require operative intervention. Occasionally an untorn periosteum may offer resistance to the reduction of a displaced epiphysis and it may be necessary to divide this tissue before the deformity can be corrected. Recurrence of deformity in an epiphyseal separation may be due to a complicating fracture of

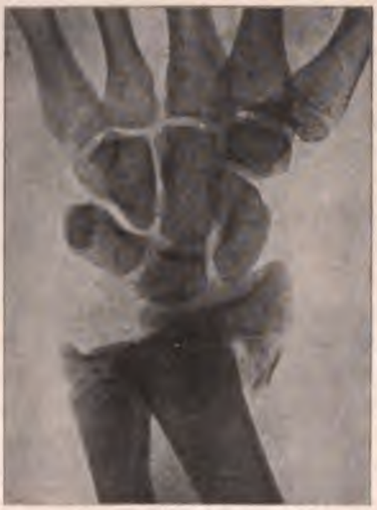

Fig. 392.

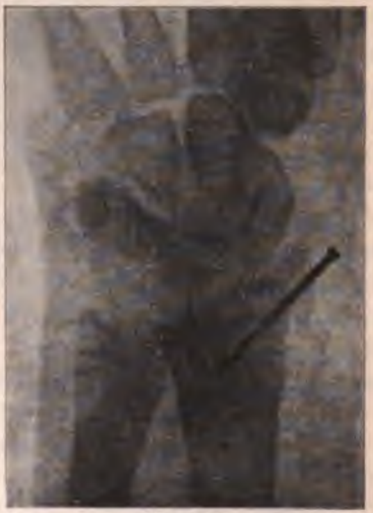

Fig. 393.

Fig. 392.—Skiagram showing radial epiphysis displaced to the radial side and a portion of the shaft of the bone carried with it. (Haubold—*Journal A. M. A.*)

Fig. 393.—Skiagram showing the detached fragment nailed to the shaft of the bone. (Haubold—*Journal A. M. A.*)

the diaphysis (see Fig. 349) and to prevent this tendency to displacement it may be necessary to wire the fragments of the diaphysis together.

Compound fractures of the lower end of the radius should be treated according to the principles as laid down under the heading of "Treatment of Compound Fractures and Dislocations," page 789.

In some cases of comminution of the lower end of the bone a circular wire will so bind the fragments together that the comminuted bony area is brought closer together and the deformity lessened. In other cases the comminution may be so extensive that operative procedure is not advisable.

Old cases of Colles' fracture with deformity and pronounced loss of function may require operation for the correction of the deformity and the breaking up of adhesions. This operation, however, should not be undertaken without a careful study of the case including an X-ray examination. One should determine, as far as possible, how much of the loss of function is due to the deformity, and how much is the result of joint and tendon adhesions, and whether or not there is a rarifying osteitis of the lower end of the radius. The loss of function is more often due to adhesions than to deformity, and hence the greatest good will, in most cases, result from a breaking up of these adhesions under anesthesia, without incision of the parts or refracture of the bone. Recent cases may be refractured without incision, provided the condition is not more than three or four weeks old. It is usually best, however, to produce refracture through an incision since more accurate work can be done in this way.

After-Treatment.—The case should be seen daily for the first few days to adjust the dressings to the varying size of the forearm and wrist during the onset and subsidence of traumatic swelling. Recurrence of deformity should be watched for and corrected if it occurs. Disturbance of the circulation or pain (especially in the region of the three pressure points) calls for readjustment of the dressings and inspection of the region of fracture. The three pressure points just referred to are the head of the ulna, the bases of the second and third metacarpals and the thenar eminence. Undue pressure at these points may lead to sloughing of the soft tissues which is a painful, annoying and serious complication. The lower end of the anterior splint should be cut away on the radial side to avoid pressure on the thenar eminence as already described in the treatment of "Fractures of the Radial and Ulnar Shafts" on page 224. The posterior splint should be well padded opposite the hand and wrist to avoid undue pressure on the head of the ulna and the bases of the metacarpals. If unusual difficulty is experienced in avoiding pressure on these points the posterior splint may have holes drilled through it corresponding to these prominences and the padding reapplied. Pain should not be pronounced after six or eight hours. The fingers must be moved daily during the entire course of the treatment. Immobilization of the fingers is followed by a loss of function which is probably worse than the sum total of untoward symptoms seen in untreated cases. It is much more important to secure a good functional result than it is to have the fragments in perfect anatomical relation, and it must not be forgotten that function depends more on the early and free passive motion of the fingers and thumb during treatment than on anything else. The older the patient the more important is passive motion. At the end of a week or ten days the posterior splint may be dispensed with, and both may be discarded, in the average case, two weeks from the time of accident. A strip of adhesive may then be placed about the wrist and the forearm carried in a sling with the hand hanging dependent in a position of ulnar flexion. In some cases the posterior splint may be retained for a week or ten days longer as a precaution against external violence. This is particularly advisable in the treatment of children. Old patients should be allowed more time for union to take place. Un-

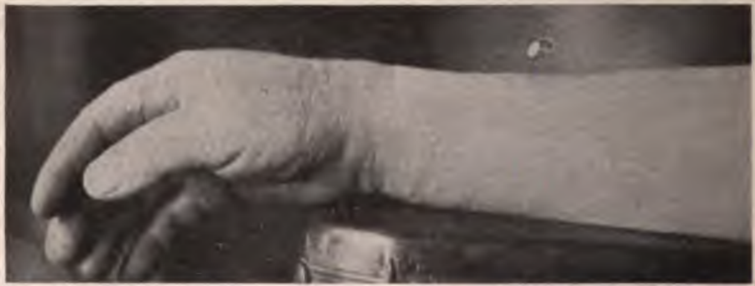

Fig. 394.—Colles' fracture about twenty-four hours following accident. Displacement of fragment slight but traumatic reaction pronounced. Swelling masks deformity to great extent. It is during the first twenty-four or forty-eight hours that there is danger of the circulation being interfered with as a result of the forearm swelling within the dressings. It is therefore imperative that the first dressings be loosely applied and the member closely watched for signs of strangulation. (See Figs. 318, 319 and 320.)

necessary strain to the wrist should be avoided for a month or more following removal of dressings, but the patient should be urged to use wrist and fingers freely so that function may be fully restored. In favorable cases gentle passive motion of the wrist should be begun as early as the end of a week or ten days following injury and kept up daily until union is present and function restored. Hot water and massage are of service in restoring the parts to normal free function and should be persisted in until recovery is complete. The after-treatment of atypical fractures and epiphyseal separations of the lower end of the radius involves the same principles as already given in the after-care of a typical Colles' fracture.

Prognosis.—Bony union is well established at the end of three weeks in the healthy young adult. Complete supination will usually be the last motion to be fully restored; this is particularly true in instances in which the lower radio-ulnar articulation has

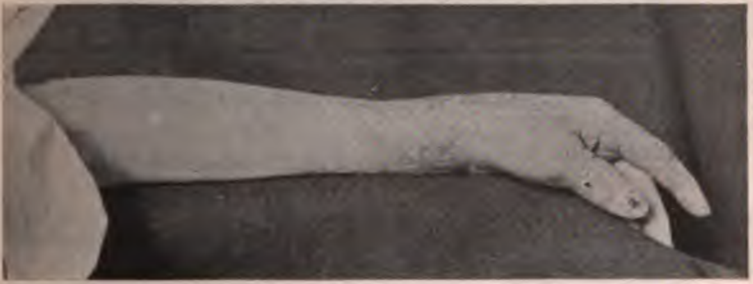

Fig. 395.

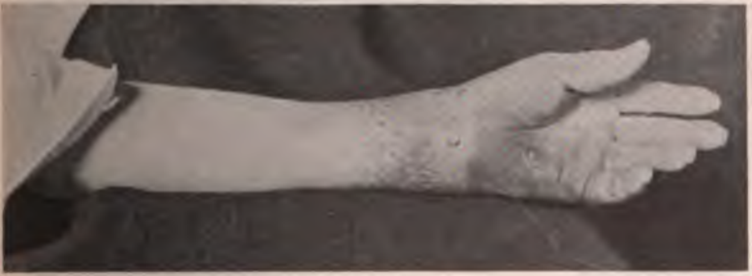

Fig. 396.

Figs. 395 and 396.—Characteristic deformity following incomplete reduction of an oblique Colles' fracture. Note slight silver-fork deformity and transverse thickening of the wrist which results from rupture of the lower radio-ulnar ligament of fracture of ulnar styloid. Lateral and ventral slumping of lower end of ulna apparent. Case first seen by author at time this photograph was taken.

the hand. Neither the anterior nor the posterior type of luxation of the ulnar head occurs as a complication of Colles' fracture and as isolated injuries the symptoms of these two dislocations are too characteristic and pronounced to require differentiation. Inward luxation of the ulnar head, however, is a very common complication of Colles' fracture and is frequently overlooked. Broadening of the wrist, with inward and forward slumping of the ulnar head, is indicative of this complication. On palpation, the lower end of the ulna is found less firmly attached to the radius than normal. It may be possible to palpate the fractured styloid. It is usually not difficult to differentiate fractures and luxations of the carpus from Colles' fracture, yet lesions of the carpus accompanying Colles' fracture are not very uncommon and may be overlooked. The carpus should be examined for deformity and crepitus. If doubt exists after the wrist is thoroughly examined it is advisable to resort to the X-ray. Thus the diagnosis is established, the details of the lesion or lesions are disclosed and the parts will have been subjected to the least possible manipulation and trauma. When, on the other hand, the presence of fracture is apparent on examination and the deformity has been immediately corrected, a Röntgenogram should be made to determine the completeness of reduction, to verify the diagnosis and to exclude associated lesions of adjoining bones.

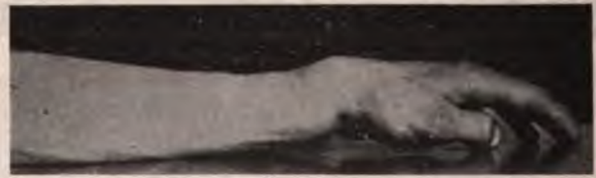

Fig. 378.

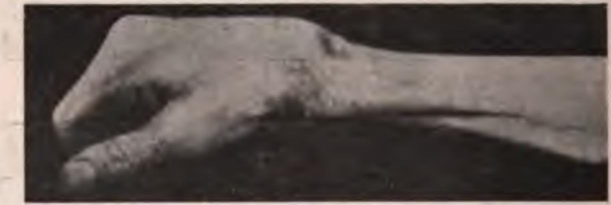

Fig. 379.

Figs. 378 and 379.—Photographic comparison of Colles' fracture and backward dislocation of wrist. The dislocation (lower picture) shows a much more abrupt deformity, except where the tendons cross the articulation and the ventral deformity is much lower.

The differentiation of Colles' fracture from simple sprain of the wrist is at times more confusing than would at first appear. Swelling of the parts and distention of the synovial sheaths following a sprain may simulate, to some extent, the deformity of Colles' fracture. Unless one is familiar with the condition and a careful examination is made, a sprain may be mistaken for a fracture, or

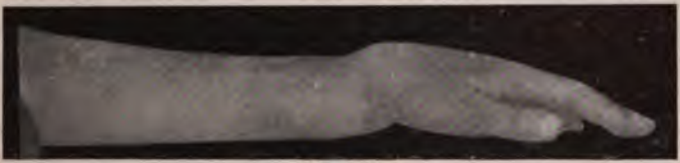

Fig. 380.

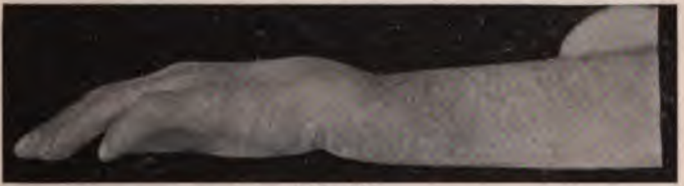

Fig. 381.

Figs. 380 and 381.—Radial and ulnar views of Colles' fracture just before reduction. (See Figs. 382 and 383.)

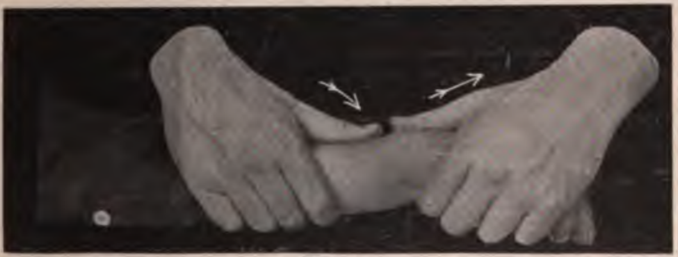

Fig. 382.

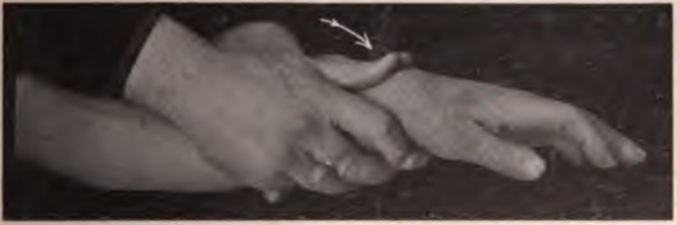

Fig. 383.

Figs. 382 and 383.—Two methods of grasping the wrist in reducing Colles' fracture. The arrows indicate the lines of force employed.

efficient when the break is transverse and impaction exists. If the lower radio-ulnar articulation remains intact reduction can sometimes be effected by strong ulnar flexion of the wrist. By this method the radio-ulnar articulation is used as a fulcrum in forcing the lower radial fragment back into position. Care should be exercised, however, not to place more strain on the articulation than it will stand as otherwise it may be broken up, thus increasing the damage instead of correcting the deformity. After the displacement of the radial fracture has been corrected lateral pressure should be exerted on the lower end of the ulna to force the ulnar head home against the sigmoid cavity of the radius; thus correcting the lateral and forward displacement of the ulna.

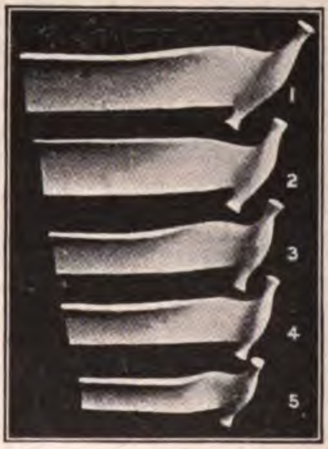

Fig. 388.—The Walker splint. Made in "rights" and "lefts" and in five sizes for the treatment of Colles' fracture.

Numerous splints have been devised to prevent recurrence of deformity and they are of some advantage, though their value has been greatly exaggerated. Special padding and splints of special design should never be used with the idea of actively correcting deformity. The displacement should be overcome as fully as possible at the time of reduction and the most that should be attempted in fixation of the parts is to prevent the recurrence of the deformity. The various types of dressing which have been employed in the fixation of Colles' fracture are too numerous to mention. The most important element in the treatment of these cases is to secure an accurate reduction and firm engagement of the fragments, and to then protect the parts from strains which might disturb the fragments. The nature of the fixation employed will depend on the tendency to recurrence of deformity and the age and temperament of the patient. An adult may in most cases be depended upon to avoid disturbing the parts during the after-treatment and to follow the instructions given by the surgeon. On the other hand an active child cannot be trusted and the wrist should be so firmly dressed that the parts are not likely to be accidentally disturbed.

When therefore a solid engagement can be obtained in a dependable adult the wrist may be encircled with a strip of adhesive plaster and the forearm carried in a sling. The hand should not be supported by the sling but is allowed to hang dependent from the wrist in a position of ulnar flexion. Excellent results can be obtained in this way, provided a solid engagement of the fragments has been secured and the patient follows directions and does not disturb the parts. If a short, properly padded dorsal splint is secured in position with a circular strip of adhesive plaster the immobilization will be found more secure than that obtained by the encircling strip of adhesive alone. When the short dorsal splint is employed appropriate padding should be placed between the adhesive and the ventral surface of the wrist. In instances in which there has been much comminution and the tendency to recurrence of deformity cannot be overcome during reduction this method is entirely too insecure and should not be employed. Under

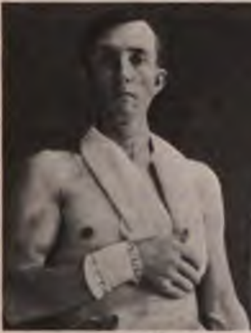

Fig. 389.

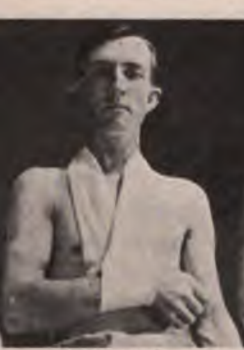

Fig. 390.

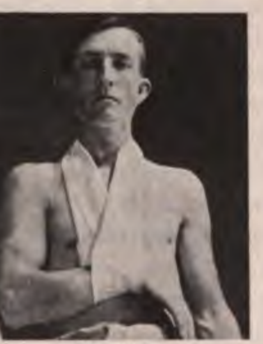

Fig. 391.

Fig. 389.—Short splints applied to wrist and held in position by circular strap of adhesive.

Fig. 390.—Shows proper position of wrist and hand. Wrist is carried in ulnar flexion.

Fig. 391.—Shows improper method of carrying wrist and hand. Forearm pronated and wrist flexed.

these circumstances the anterior and posterior splints such as used in the treatment of fractures of the forearm will, in most cases, serve the purpose better. Heavy padding of the posterior splint below the plane of fracture and of the anterior splint above the break will tend to prevent the return of the silver-fork deformity. The best material for this special padding is saddler's felt which may be obtained from any harness shop. It is elastic, holds its shape well and may be cut into pads of desired proportions. The splints should be a little broader than the forearm in its thickest part and should be loosely enough applied to avoid constriction. The forearm should not be bandaged before the splints are placed in position. The padding is never used with the expectation of actively forcing the fragments back into place but only for the purpose of preventing redisplacement. One splint, usually the anterior, is secured in place by strips of adhesive. The opposite splint is then applied and may be removed separately during the after-treatment without depriving the fracture of the support offered by the opposite splint. (See Figs. 307 to 312.) In this way the anterior splint supports the forearm and wrist while the surgeon is inspecting the parts and readjusting the dressing. It is of paramount importance that free circulation be present after the dressings are in place. During the first few days following the injury due allowance should be made for the swelling which comes with traumatic reaction. Constriction may be readily detected by examining the nails. The dangers of too tight bandaging and strangulation of the forearm have already been mentioned under "Fractures of Bones of the Forearm." The Bond splint and others of the same type which maintain the wrist in a position of ulnar flexion are of service in some cases but their value has been greatly overestimated. It has been customary for years to consider the position of the hand as exerting great influence on the recurrence of deformity. As a matter of fact there are a few conditions in which the position of the hand affects the position of the fragment, but in nearly all fractures in this region the prime requisite in avoiding the recurrence of deformity is the proper reduction of the deformity and firm engagement of the fragments. If the lower radio-ulnar articulation remains intact ulnar flexion will tend to hold the lower radial fragment in reduction, but if the articulation has been broken up, this position will only increase the displacement of the ulnar head. Comminution of the lower end of the radius, crushing of the cancellous tissue in this region and obliquity in the plane of fracture are the most common causes of recurrence of deformity following proper reduction, and the position of the hand during the after-treatment has little influence in maintaining reduction when these conditions exist. Flexion of the wrist places the extensor tendons on the stretch and they are thus supposed to exert a splinting action on the fragments. Ulnar flexion throws more strain on the ulna and relieves the radius, to some extent, of the shortening effect of the muscles of the forearm. It is questionable, however, if either of these positions makes enough difference to be of practical importance in the treatment of Colles' fracture. Extensive comminution of the lower end of the radius renders the fragments difficult to maintain in good reduction and it is here that ulnar flexion will be found of most value, provided the lower radio-ulnar articulation has not been broken up.

The reduction of Barton's fracture involves the same principles as already described in correcting the deformity of Colles' fracture. In atypical fractures of the lower end of the radius the surgeon must be guided by the nature of the fracture and the character of the displacement. If the type of the fracture is fully appreciated the surgeon will be better able to correct the deformity and hence the value of the X-ray, especially in instances in which difficulty is experienced in correcting the displacement. Occasionally cases are encountered in which reduction cannot be accomplished without resorting to open incision. The local use of the ice bag during the first twenty-four to forty-eight hours will be found of great service in controlling the traumatic reaction, especially in cases in which the causative trauma has been severe.

Operative Treatment.—Operation is sometimes indicated when a satisfactory reduction cannot be otherwise obtained. A small fragment of bone may become interposed between the fractured surfaces and require removal before the deformity can be corrected. Direct reposition of the fragments through the incision will be all that is required in most cases.

The common fracture of the lower end of the radius is best approached through a longitudinal incision on the outer side of the wrist. This incision exposes the radial artery and nerve and the extensors of the thumb. Under cover of the posterior lip of the wound will be found the radial extensors of the carpus. The course of the radial artery is sometimes anomalous, winding around the lower fourth of the radius instead of passing through the anatomical snuff-box. This condition may be recognized by palpating the artery even before the incision is made. Oblique Colles' fracture and some of the atypical breaks seen in the lower end of the radius may need some form of internal fixation to prevent recurrence of deformity. The placing of this material will depend entirely on the nature of the fracture and the character of the displacement. In oblique fractures which cannot otherwise be maintained in reduction a small loop of wire passing through the fragments will often accomplish all that is desired. In instances of pronounced radial displacement of the lower fragment a satisfactory fixation may be obtained in some cases by nailing the lower fragment to the upper as shown in Fig. 393. Epiphyseal separations seldom require operative intervention. Occasionally an untorn periosteum may offer resistance to the reduction of a displaced epiphysis and it may be necessary to divide this tissue before the deformity can be corrected. Recurrence of deformity in an epiphyseal separation may be due to a complicating fracture of

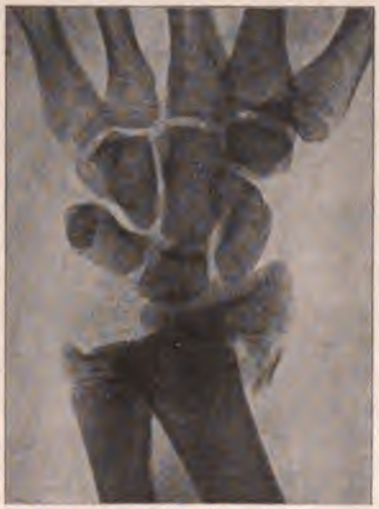

Fig. 392.

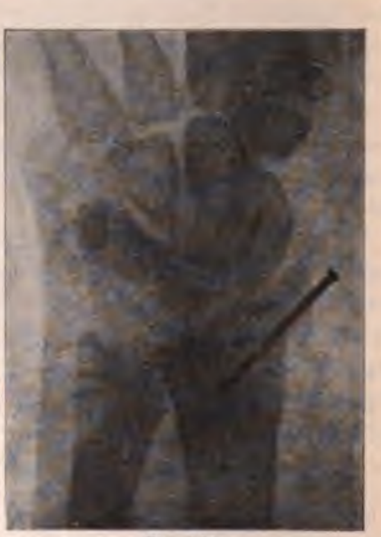

Fig. 393.

Fig. 392.—Skiagram showing radial epiphysis displaced to the radial side and a portion of the shaft of the bone carried with it. (Haubold—*Journal A. M. A.*)

Fig. 393.—Skiagram showing the detached fragment nailed to the shaft of the bone. (Haubold—*Journal A. M. A.*)

the diaphysis (see Fig. 349) and to prevent this tendency to displacement it may be necessary to wire the fragments of the diaphysis together.

Compound fractures of the lower end of the radius should be treated according to the principles as laid down under the heading of "Treatment of Compound Fractures and Dislocations," page 789.

In some cases of comminution of the lower end of the bone a circular wire will so bind the fragments together that the comminuted bony area is brought closer together and the deformity lessened. In other cases the comminution may be so extensive that operative procedure is not advisable.

Old cases of Colles' fracture with deformity and pronounced loss of function may require operation for the correction of the deformity and the breaking up of adhesions. This operation, however, should not be undertaken without a careful study of the case including an X-ray examination. One should determine, as far as possible, how much of the loss of function is due to the deformity, and how much is the result of joint and tendon adhesions, and whether or not there is a rarifying osteitis of the lower end of the radius. The loss of function is more often due to adhesions than to deformity, and hence the greatest good will, in most cases, result from a breaking up of these adhesions under anesthesia, without incision of the parts or refracture of the bone. Recent cases may be refractured without incision, provided the condition is not more than three or four weeks old. It is usually best, however, to produce refracture through an incision since more accurate work can be done in this way.

After-Treatment.—The case should be seen daily for the first few days to adjust the dressings to the varying size of the forearm and wrist during the onset and subsidence of traumatic swelling. Recurrence of deformity should be watched for and corrected if it occurs. Disturbance of the circulation or pain (especially in the region of the three pressure points) calls for readjustment of the dressings and inspection of the region of fracture. The three pressure points just referred to are the head of the ulna, the bases of the second and third metacarpals and the thenar eminence. Undue pressure at these points may lead to sloughing of the soft tissues which is a painful, annoying and serious complication. The lower end of the anterior splint should be cut away on the radial side to avoid pressure on the thenar eminence as already described in the treatment of "Fractures of the Radial and Ulnar Shafts" on page 224. The posterior splint should be well padded opposite the hand and wrist to avoid undue pressure on the head of the ulna and the bases of the metacarpals. If unusual difficulty is experienced in avoiding pressure on these points the posterior splint may have holes drilled through it corresponding to these prominences and the padding reapplied. Pain should not be pronounced after six or eight hours. The fingers must be moved daily during the entire course of the treatment. Immobilization of the fingers is followed by a loss of function which is probably worse than the sum total of untoward symptoms seen in untreated cases. It is much more important to secure a good functional result than it is to have the fragments in perfect anatomical relation, and it must not be forgotten that function depends more on the early and free passive motion of the fingers and thumb during treatment than on anything else. The older the patient the more important is passive motion. At the end of a week or ten days the posterior splint may be dispensed with, and both may be discarded, in the average case, two weeks from the time of accident. A strip of adhesive may then be placed about the wrist and the forearm carried in a sling with the hand hanging dependent in a position of ulnar flexion. In some cases the posterior splint may be retained for a week or ten days longer as a precaution against external violence. This is particularly advisable in the treatment of children. Old patients should be allowed more time for union to take place. Un-

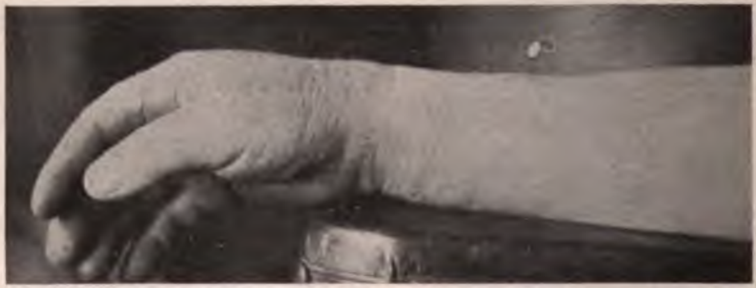

Fig. 394.—Colles' fracture about twenty-four hours following accident. Displacement of fragment slight but traumatic reaction pronounced. Swelling masks deformity to great extent. It is during the first twenty-four or forty-eight hours that there is danger of the circulation being interfered with as a result of the forearm swelling within the dressings. It is therefore imperative that the first dressings be loosely applied and the member closely watched for signs of strangulation. (See Figs. 318, 319 and 320.)

necessary strain to the wrist should be avoided for a month or more following removal of dressings, but the patient should be urged to use wrist and fingers freely so that function may be fully restored. In favorable cases gentle passive motion of the wrist should be begun as early as the end of a week or ten days following injury and kept up daily until union is present and function restored. Hot water and massage are of service in restoring the parts to normal free function and should be persisted in until recovery is complete. The after-treatment of atypical fractures and epiphyseal separations of the lower end of the radius involves the same principles as already given in the after-care of a typical Colles' fracture.

Prognosis.—Bony union is well established at the end of three weeks in the healthy young adult. Complete supination will usually be the last motion to be fully restored; this is particularly true in instances in which the lower radio-ulnar articulation has

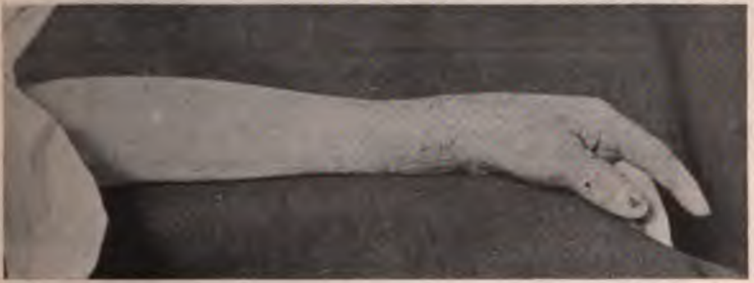

Fig. 395.

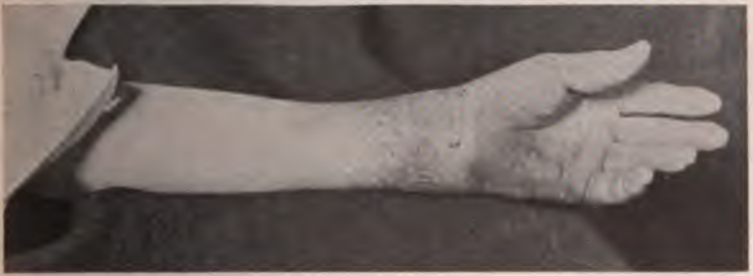

Fig. 396.

Figs. 395 and 396.—Characteristic deformity following incomplete reduction of an oblique Colles' fracture. Note slight silver-fork deformity and transverse thickening of the wrist which results from rupture of the lower radio-ulnar ligament of fracture of ulnar styloid. Lateral and ventral slumping of lower end of ulna apparent. Case first seen by author at time this photograph was taken.

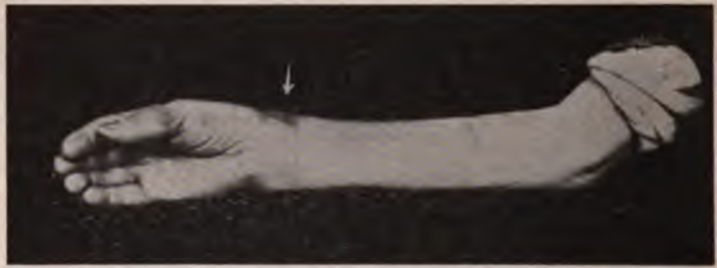

Fig. 397.—Another case of broadened wrist following incomplete reduction of Colles' fracture. Patient presents himself for treatment because of slow recovery and inability to use hand. Wrist stiff, painful, etc. Case first seen by author at time this photograph was taken.

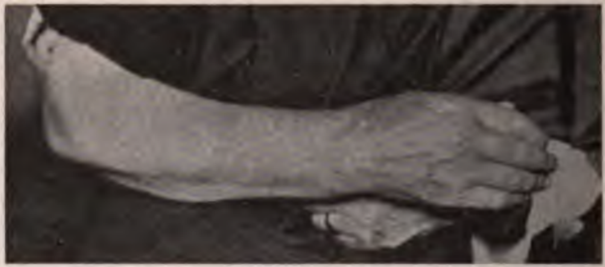

Fig. 398.—Another case of slow and incomplete recovery following Colles' fracture. In this case the reduction has been excellent but the after-treatment has been faulty in that the patient's hand, wrist and fingers were completely immobilized for a period of six weeks. Adhesions between the joint surfaces and within the tendon sheaths have resulted and the X-ray discloses an osteitis of the carpus. Patient 55 years of age. (See Fig. 399.) Case first seen by author at the time this picture was taken.

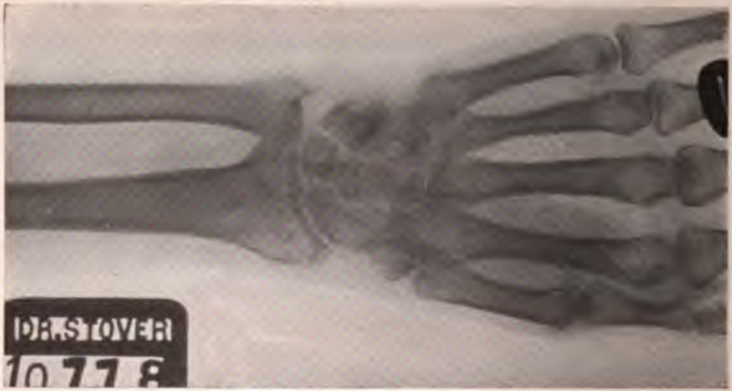

Fig. 399.—Osteitis of the carpus and bases of the metacarpals following a Colles' fracture in which the condition was treated by prolonged immobilization. This condition is not uncommon in patients past middle life in which the parts are immobilized for too long a period. A condition such as this is very much easier to avoid than it is to treat, after it has become established. It should be remembered that the possibility of fracture in breaking up adhesions is greater in a case like this than it would be if the carpal bones were normal.

been broken up or in cases in which the fracture has entered the sigmoid cavity of the radius. In older persons restoration of function is much slower and adhesions in and about the tendon sheaths and in the wrist joint are more prone to occur and are important elements in restricting motion. The complete restoration of function depends more on the early and persistent use of passive motion than on the anatomical reduction of the displacement. The prognosis, therefore, is more or less directly dependent on the proper use of passive motion during the after-treatment. In some cases joint and tendon adhesions and rarifying osteitis develop in spite of the most careful treatment (see Fig. 399) but these con-

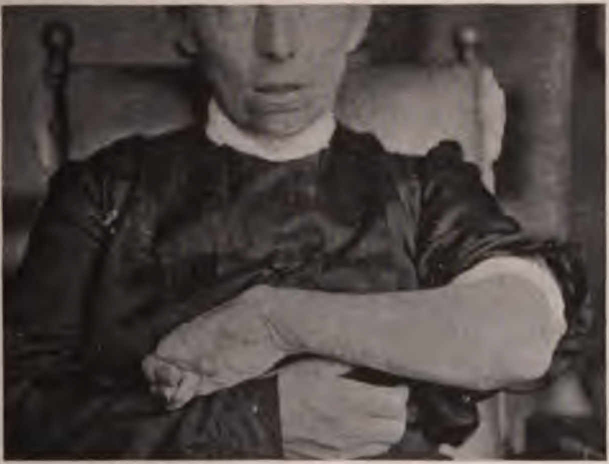

Fig. 400.

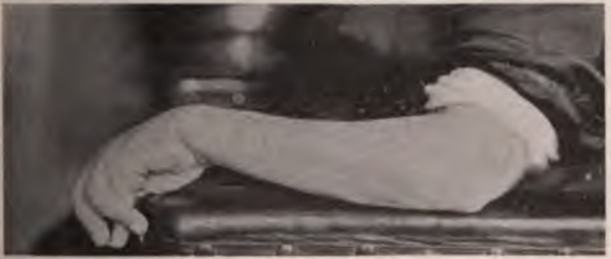

Fig. 401.

Figs. 400 and 401.—Contracture of the hand following Colles' fracture. Nerves injured either at the time of the accident or during the after-treatment from too tight bandaging. Indication of beginning contracture first noted at the time the splints were removed. First seen by author about eighteen months after the injury.

ditions are fortunately rare in cases receiving the proper care during the after-treatment. Restricted motion of the wrist and fingers, and slight pain especially in the region of the ulnar styloid, are conditions which may persist for months but will, as a rule, pass off with massage and hot applications. The more faithfully passive motion is carried out during the time the wrist is immobilized the less pronounced will be these annoying sequelæ. Destruction of bony tissue in the lower end of the radius, such as occurs in impaction and extensive comminution, may render accurate reduction, even under operation, impossible and hence some deformity will result, but this does not necessarily mean any considerable loss of function.

An ordinary uncomplicated Colles' fracture which is properly reduced and treated should be followed, in a healthy adult, by complete restoration of function. In older patients a perfect functional result will be more difficult to obtain. In atypical fractures of the lower end of the radius the prognosis will vary with the severity and character of the fracture. Uncomplicated epiphyseal separations of the lower end of the radius should be followed by perfect results both functionally and anatomically if the epiphysis is properly reduced. Disturbances in the growth of the radius are rarely seen following epiphyseal separations, if anything like a perfect reduction has been obtained. Even in cases in which pronounced displacement is allowed to persist defective growth is rarely seen.

CHAPTER XX.

INJURIES TO THE CARPUS.

Under this heading is included: radio-carpal luxations (commonly spoken of as dislocations of the wrist), medio-carpal luxations, and fractures and dislocations of the individual carpal bones.

Surgical Anatomy.—The strength of the wrist is such that when subjected to violence fracture is more likely to occur above or below this region than in the carpus itself. The ligaments binding the bones of the forearm to the carpus, those between the

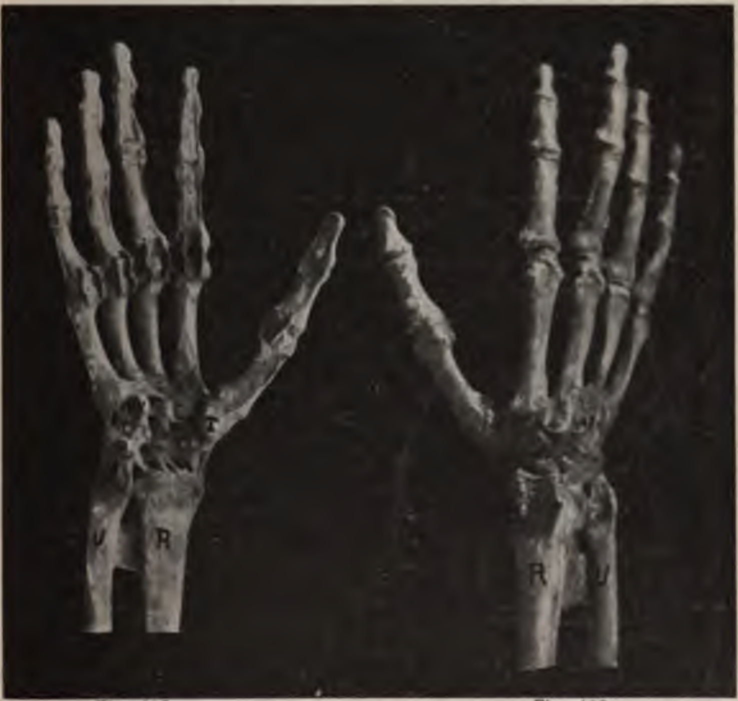

Fig. 402. Fig. 403.

Figs. 402 and 403.—Ventral and dorsal views of ligaments of hand. *U.*, ulna; *R.*, radius; *U.N.*, uncinate; *P.*, pisiform; *T.*, trapezium.

carpus and metacarpus, and the inter-carpal ligaments are all heavy and strong but the main strength of the wrist is dependent on the numerous and heavy tendons which pass from the forearm to the hand, and are bound firmly to the bones by the annular ligaments and the fibrous compartments through which they run. It should be remembered that though the carpus is actuated by the flexors and extensors passing from the forearm to the hand, only one of these muscles is inserted into the carpus. The flexor carpi ulnaris is inserted into the pisiform but since this bone is functionally a sesamoid bone and not truly a bone of the carpus we may consider the carpus as free from the insertions of the muscles of the forearm. Thus the carpus is actuated indirectly through the metacarpal bones. Some of the intrinsic muscles of the hand arise from the ventral surface of the lower row of carpal bones, but their action is on the metacarpus rather than the carpus.

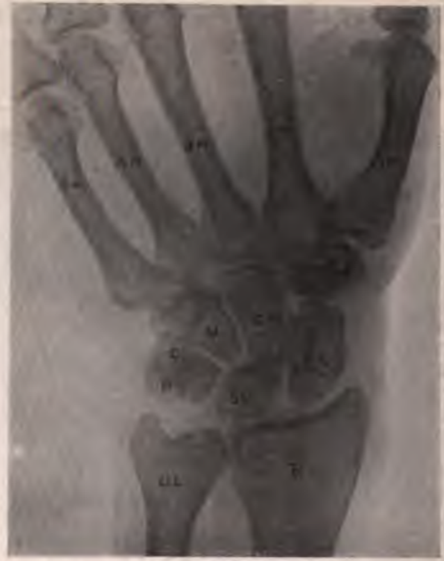

Fig. 404.—Bones of normal wrist. *1 M*, *2 M*, *3 M*, *4 M*, and *5 M* indicate metacarpals; *Tm.*, Trapezium; *Td.*, Trapezoid; *O. M.*, Os Magnum; *U.*, Unciform; *C.*, Cuneiform; *P.*, Pisiform; *Sl.*, Semilunar; *Sc.*, Scaphoid; *Ul.*, Ulna; *R.*, Radius.

The *radio-carpal or wrist joint* is a condyloid articulation. The articular surface of the lower end of the radius and the inferior surface of the triangular fibro-cartilage form the socket, while the upper surfaces of the scaphoid, semilunar and cuneiform bones form the condyle. Motion of this articulation is possible in every direction except axial rotation. The plane of the radio-carpal joint is on a level with the tip of the ulnar styloid. Luxations of this joint may take place in any direction but are extremely rare; only a few cases of each type having been recorded. Colles' fracture is frequently mistaken for dislocation of the wrist, and the cases of this luxation reported prior to the advent of the X-ray are particularly untrustworthy. Dislocation of the wrist complicated by fracture of the lower end of the radius is not nearly as

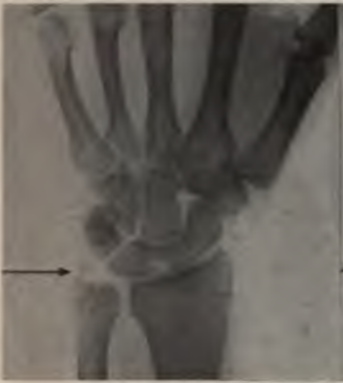

Fig. 405.

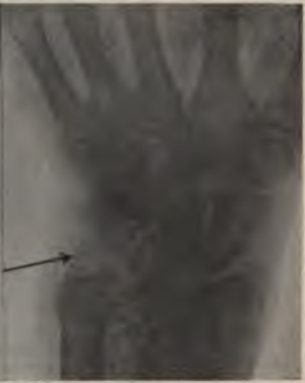

Fig. 406.

Fig. 405.—Old Colles' fracture. Triangulare present. Indicated by arrow.
Fig. 406.—Another old Colles' fracture with anomalous triangulare.

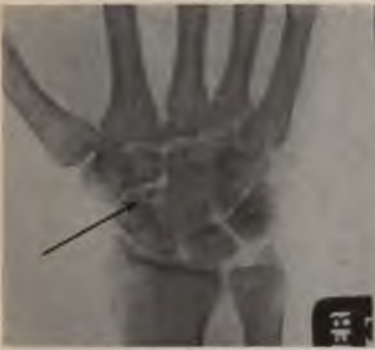

Fig. 407.

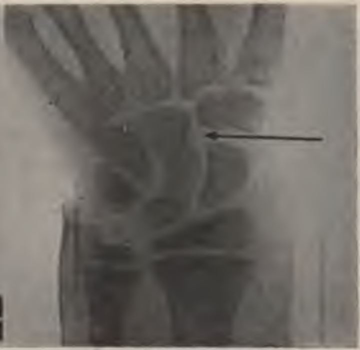

Fig. 408.

Fig. 407.—Example of anomalous centrale.

Fig. 408.—Space in carpus corresponding to site of centrale. Anomalous condition present though the embryonic elements entering into formation of centrale show no signs of ossification.

uncommon as the pure luxation. When the carpus is displaced backward and upward and the posterior lip of the radius is broken off and displaced with the carpus, the condition is known as Barton's fracture and has been described under "Fractures of the Lower End of the Radius." When the reverse condition obtains, that is, when the ventral lip of the radius is broken off and displaced forward and upward with the carpus, it is known as a "reversed Barton's fracture." Lateral luxations of this joint, either with or without fracture, are too rare to be considered as a type. It is probable that a large proportion of the reported cases of luxation of the radio-carpal joint (especially those not examined with the X-ray) have in reality been Colles' fractures or at least fracture-luxations of Barton's type.

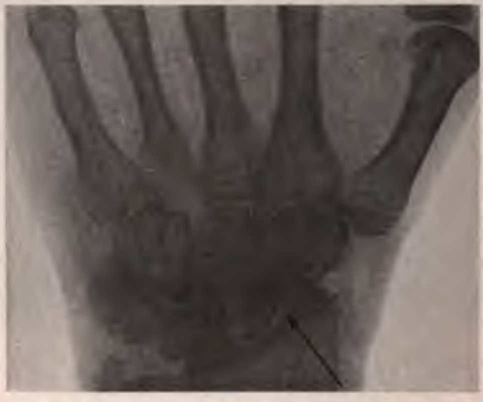
Fig. 409.—Old united fracture of scaphoid.

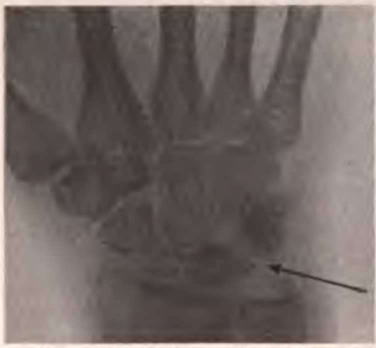
Fig. 410.—Fracture of semilunar.

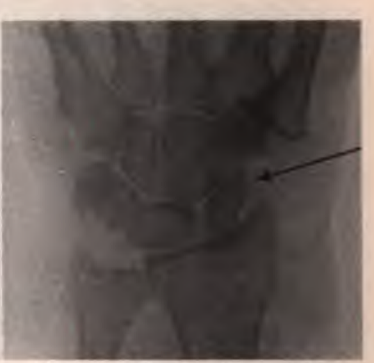
Fig. 411.—Fracture of scaphoid.

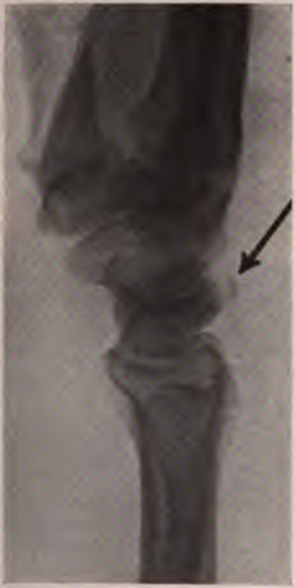

Fig. 412.—Fractured cuneiform.

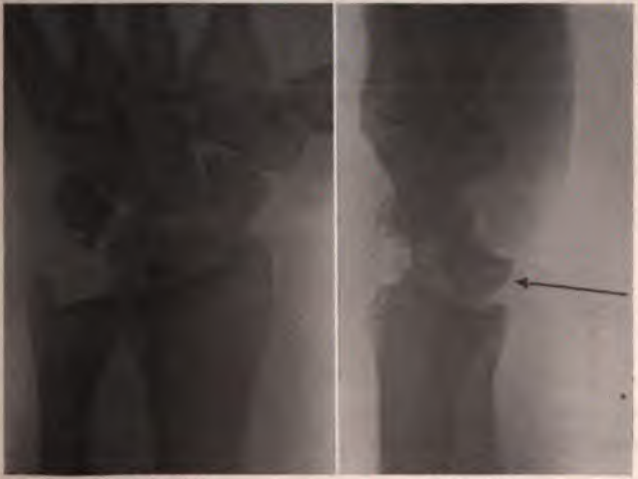

Fig. 413. Fig. 414.

Figs. 413 and 414.—Antero-posterior and lateral views of luxated semilunar.

Luxations of the *medio-carpal articulation* probably never occur as a pure dislocation, following accurately the lines of the medio-carpal articulation. They are usually complicated by fracture of one or more of the carpal bones with displacement of the fragments.

Isolated fractures and luxations of the carpal bones are not very uncommon injuries and are now known to accompany fractures of the lower end of the forearm more frequently than was supposed prior to the establishment of the Röntgen ray as a diagnostic measure.

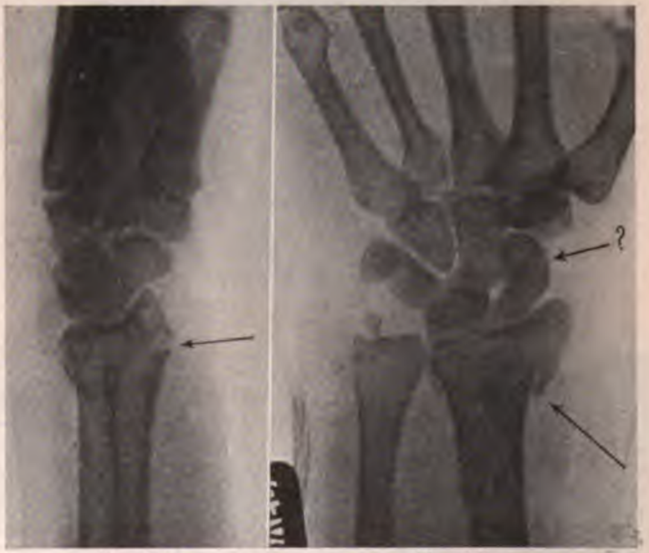

Fig. 415. Fig. 416.

Figs. 415 and 416.—Old Colles' fracture showing un-united fracture of ulnar styloid and an abnormal condition in the scaphoid. Either an old fracture or a "divided scaphoid."

A study of the X-ray records of these injuries has brought up a most important and confusing subject; namely, the anomalies of the carpal bones. The development of the carpus shows considerable variation and anomalies of the bones of the carpus are comparatively of frequent occurrence. It will be impracticable, here, to enter into all the possible variations; the reader is referred to the most excellent and thorough work done by Thomas Dwight, as set forth in his book on "Variations of the Bones of the Hand and Foot." Occasion will be taken, however, to call attention to some of the more common anomalies which are, at times, confounded with fracture. Anomalies may consist of supernumerary bones, due either to the persistence of embryonic elements or to the division of one or more of the carpal bones. Another form of anomaly is seen in instances in which two or more of the carpal bones are fused, or in which fusion has taken place between an accessory bone and one of the bones of the carpus. These anomalies of fusion are of anatomic interest only, since there is no occasion for mistaking them for fractures as is the case when supernumerary bones are present or when one of the bones of the carpus is divided.

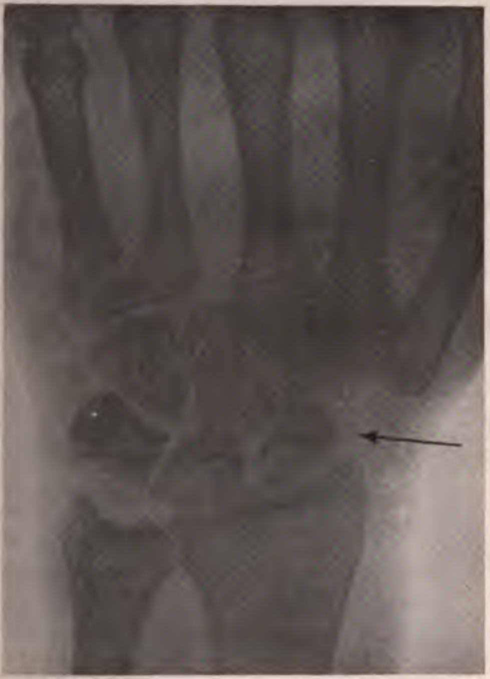

Fig. 417.—"Divided scaphoid."

The following anomalies are described in detail by Dwight, and from a surgical standpoint are the most important occurring in the carpus.

The *scaphoid* is not uncommonly divided, either partially or completely, into two lateral portions. An example of this condition is shown in Fig. 417. This anomaly resembles fracture of the scaphoid.

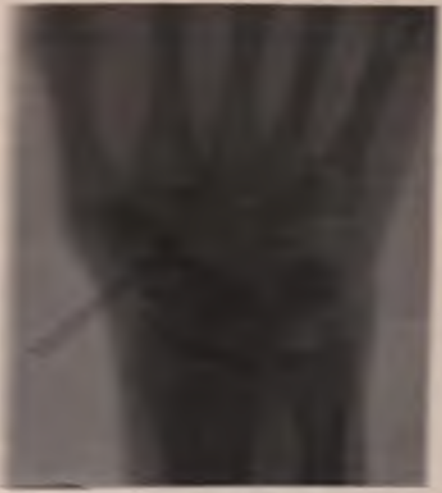

Fig. [illegible].—Fractured [illegible] and head with os magnum.

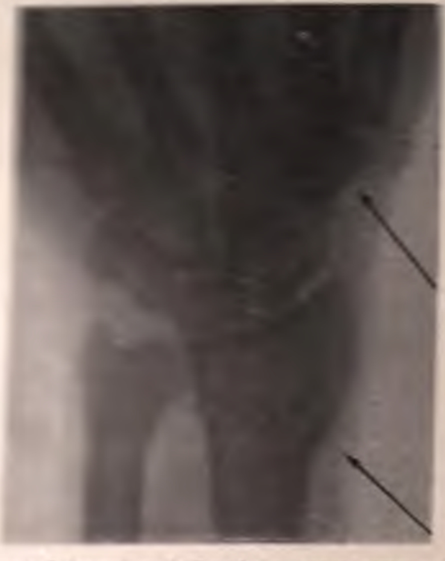

Fig. [illegible].—Fractured trapezium indicated by upper arrow. Colles' fracture indicated by lower arrow.

The *semilunar* sometimes gives the appearance of being divided into a palmar and a dorsal portion, but this is probably due to an accessory bone to be spoken of later (the epilunatum).

The *cuneiform* varies considerably in both size and form but seldom presents any anomaly which might be mistaken for fracture.

The *pisiform* may show some variations in size and shape; there may be an accessory pisiform.

The hamular process of the *unciform* may be separate from the body of the bone and the line of division may be mistaken for a fracture.

The *epilunatum* and *hypolunatum* are two accessory bones which (when present) are situated at the tips of the crescentic-shaped semilunar. The dorsal anomaly (the epilunatum) is more frequent and usually of larger size than the hypolunatum which occurs opposite the ventral horn of the semilunar. The epilunatum is sometimes well developed while the semilunar is correspondingly smaller than usual. This condition gives the appearance of a divided semilunar and may be mistaken for fracture.

The *styloid process of the middle metacarpal* is sometimes free and appears as a supernumerary bone in the carpus.

The *centrale* is a supernumerary ossicle sometimes seen between the os magnum, scaphoid and trapezoid. An example of this condition is shown in Fig. 407. Fig. 408 shows the same condition except that the anomalous structure has never ossified, though the space for its accommodation persists.

Fig. 405 shows an example of the *triangulare* which may be mistaken for a fractured ulnar styloid.

The *radiale externum* is an accessory bone situated on the radial side of the scaphoid and is said to be the separated tubercle of the scaphoid.

The *ulnare externum* is an accessory ossicle on the ulnar side of the carpus internal to the cuneiform.

The *subcapitatum* is an accessory ossicle situated at the base of the os magnum. It is said to represent the detached base of this bone.

Numerous variations may occur in the carpus which have not been mentioned but those cited above are the ones most likely to be confused with fractures in this region. The recognition of these anomalies and their differentiation from fractures of the carpus will be considered later under Diagnosis.

The bones of the wrist begin to ossify in the following order: the os magnum and the unciform during the first year, the cuneiform during the third year, the semilunar and trapezium during the fifth year, the scaphoid during the sixth and the trapezoid during the eighth year. The pisiform begins to ossify anywhere from the eighth to the twelfth year.

The *scaphoid* is occasionally broken as a result of forces similar to those producing Colles' fracture. The line of fracture is usually across the middle of the bone as shown in Fig. 411. This fracture is not an uncommon complication of fractures of the lower end of the radius. A fragment of the scaphoid may be displaced or luxation of the entire bone may accompany fracture of the lower end of the radius or some of the other bones of the carpus. The few reported cases of uncomplicated luxation of the scaphoid have been of the backward type and were probably due to forced flexion of the wrist. Forward luxations seem to be invariably complicated by some other lesion, such as fracture of the lower end of the radius.

The *semilunar* is rarely fractured as an isolated injury. Luxation of this bone, however, is not uncommon and may be accompanied by fracture of the scaphoid or other lesions in the adjoining carpal bones or in the radius. The displacement in luxations is almost invariably forward, the bone apparently being driven from its position among the other carpal bones by forced dorsal flexion of the wrist.

The *cuneiform* is rarely injured except in general crushes of the carpus.

The *unciform* is rarely injured except as the result of direct violence, though a few cases of isolated luxation have been reported.

Both fracture and luxation are occasionally seen in the *os magnum* though the latter condition is almost always partial, or more properly a subluxation. The displacement is backward and the result of forced flexion of the wrist. Chronic subluxations of the head of the os magnum may result from heavy manual labor, especially in children.

Both fractures and luxations of the *trapezium* and *trapezoid* are exceptionally rare as isolated injuries.

The *pisiform* is known to have been broken through the action of the attached flexor carpi ulnaris and luxation of this bone has been reported a number of times. The pisiform is sometimes broken as a result of direct violence. The position of this bone is more exposed than other bones of the carpus. The displacing action of the flexor carpi ulnaris may separate the fragments. Rupture of the piso-metacarpal and piso-uncinate (the equivalents of the tendon below the bone) may result in an upward luxation of the pisiform.

In crushing injuries of the carpus any or all of the bones may be injured, depending on the nature and severity of the trauma.

Symptoms.—The symptoms accompanying fractures and luxations of the carpus depend on the nature of the injury and the position of the resultant lesion or lesions.

In *dislocations of the wrist* (radio-carpal joint) the carpus is usually displaced backward. The deformity is low and abrupt in outline and the extensor tendons stand out prominently as they pass from the dorsum of the forearm to the back of the hand. The clinical appearance of this deformity is well shown in Fig. 379. Palpation of the lower end of the radius will show that this bone is intact if the condition is a pure luxation. Pain and loss of function accompany the injury and are pronounced. Swelling

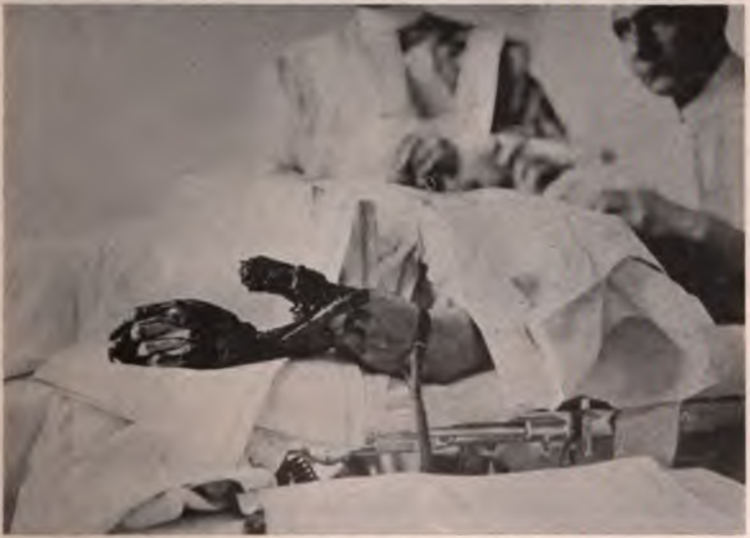

Fig. 420.—Severe compound fracture dislocation of wrist sustained in railroad accident. Skin is the only tissue connecting forearm and hand. Rubber tourniquet seen in position having been applied to control hemorrhage immediately following accident. Picture taken just prior to amputating.

develops rapidly and if the case is not seen soon after the accident the deformity is to some extent obscured. If this luxation is complicated by fracture of the lower end of the radius crepitus will be present and there is likely to be a tendency to recurrence of deformity following reduction. In the *anterior form* of luxation the deformity is of the gardener's-spade type and resembles the displacement seen in reversed Colles' fracture. The deformity, however, is lower and more abrupt in outline and the posterior lip of the lower end of the radius stands out prominently. Since this luxation is frequently complicated by fracture of the lower end of the radius crepitus may be present.

The symptoms accompanying *medio-carpal luxations* closely resemble those of dislocation of the radio-carpal articulation. The deformity, however, is slightly lower and it may be possible to palpate the proximal row of carpal bones in their normal relations with the radius. Since this luxation is practically always complicated by fracture of the carpal bones or of the lower end of the radius crepitus is to be expected. The luxation may be either forward or backward and accordingly the deformity may be either of the silver-fork or gardener's-spade variety.

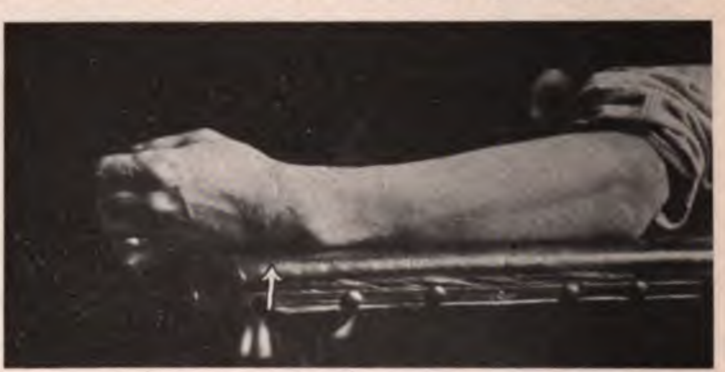

Fig. 421.—Slight deformity following compound crushing injury of the lower end of ulna and radius and the ulnar side of carpus. Wrist was caught in large gears. Picture taken some years after recovery.

The symptoms accompanying isolated fractures and luxations of the carpal bones are indistinct and not characteristic as compared with other lesions in this region. This will be found particularly true in cases in which swelling is pronounced. The following symptoms, however, are more or less peculiar to lesions of the different bones.

Fracture of the scaphoid is usually accompanied by local tenderness in the "anatomical snuff box." The hand may be slightly abducted and the vertical depth of the radial side of the carpus may be somewhat diminished if the scaphoid has been crushed or completely luxated. It may be possible to elicit crepitus and in some cases it may be accurately enough located to be recognized as emanating from the scaphoid. Isolated luxation of the scaphoid is a rare condition and the symptoms vary, according to the direction of the dislocation, whether or not the scaphoid is fractured as well as luxated and the completeness of the displacement. Palpation at the back of the wrist may reveal the absence of the scaphoid from its normal position if the luxation is ventral, or on the other hand, there may be an abnormal prominence on the dorsal aspect of the carpus if the luxation is backward. Crepitus may be present if fracture complicates the luxation.

The symptoms accompanying fracture of the *semilunar* are similar to those of fracture of the scaphoid. Fracture of the semilunar, however, rarely occurs as an isolated injury, and when crepitus is detected in this region of the carpus it is fair to presume that the lesion is situated in the scaphoid rather than in the semilunar. In forward luxations of the semilunar the displaced bone may be palpated on the ventral aspect of the wrist. In backward luxations it may be recognized as a hard prominence just below the radius and at about the middle of the carpus.

Fracture of the cuneiform is practically unknown except as a part of extensive injuries in which the carpus is crushed. The author knows of no case of isolated luxation of this bone. The symptoms to be expected, however, would resemble those accompanying fracture and luxation of the scaphoid and semilunar.

Fracture of the pisiform is not necessarily accompanied by characteristic symptoms even though the bone is more superficial than other bones of the carpus. The displacing action of the attached muscle may so separate the fragments that crepitus cannot be obtained. Pain on use of the wrist and local tenderness may be the only symptoms. In upward luxations of this bone it may be possible to recognize the altered position.

Fracture of the os magnum is accompanied by pain and tenderness in the center of the carpus, more or less loss of function and crepitus when the carpus is properly manipulated and palpated. The condition, however, is rare and easily confused with other fractures in this region. Luxation of this bone is quite rare. A number of cases of subluxation of the head of the os magnum have been reported. They have been accompanied by an undue prominence on the dorsal aspect of the carpus, especially during complete dorsal flexion of the wrist. The loss of function produced by these subluxations is surprisingly slight.

Fractures of the trapezium and *trapezoid* are extremely rare except in severe crushes of this region. They may occur, however, and are accompanied by crepitus and mobility at the base of the first or second metacarpal, as the case may be. Crepitus in the region of the base of the first metacarpal is almost always caused by Bennett's fracture and rarely by fracture of the trapezium (see "Fractures of the Metacarpals," page 297). Luxations of either of these bones is extremely rare, and since only dorsal luxations have been reported, the prominence of the displaced bone may be expected on the dorsal aspect of the carpus.

Fracture of the unciform is practically unknown except as a complication of luxation or in severe crushing injuries of the carpus. The process has been reported as broken off accompanying luxation.

Diagnosis.—Theoretically the diagnosis of fractures and luxations of these bones should be easy but the difficulty of ascertaining the exact nature of these injuries is shown by the frequency with which the diagnosis is changed after the X-ray has been employed. The appearance of the wrist is so characteristic in luxations of the radio-ulnar joint that it would seem almost impossible to fail in recognizing the nature of the injury. It is a well known fact, however, that Colles' fracture is frequently mistaken for dislocation of the wrist. One who has never seen a dislocated wrist should hesitate in pronouncing an injury of this region a dislocation unles the diagnosis has been confirmed by an X-ray examination. (See Figs. 378 and 379.) Medio-carpal luxations are extremely rare and it will be safer to make only a tentative diagnosis pending the report on the X-ray, even though one feel reasonably certain of the condition.

The size of the carpal bones and their compact arrangement are such that accurate diagnoses of isolated lesions of these bones are almost impossible. The important point to be determined by inspection and palpation is whether or not fracture or luxation exists. The treatment of the different traumatic lesions in this region is similar, and the details of the damage done may be learned by resorting to the X-ray. The carpus is most satisfactorily palpated by flexing the wrist. This position exposes the dorsal surfaces of the carpal bones and palpation will then reveal any abnormal prominence or depression. Slight passive motion while palpating the carpus in this way will usually elicit crepitus in the presence of fracture. One should not fail to use the opposite wrist as a standard of comparison.

In the interpretation of X-ray plates one should keep in mind the more common anomalies as mentioned under the heading of "Surgical Anatomy," on page 282. The Röntgenographic recognition of anomalous bones depends on the position and structure of the supernumerary ossicle and its presence in the opposite carpus. The X-ray plate should show the structure of the bones of the carpus as well as their outlines. It should be remembered in this connection that the structure of supernumerary bones is similar to that of the normal bones of the carpus. This point is of importance in distinguishing anomalous bones from fractures. The interior of each bone is composed of cancellous tissue while the surface is finished off by a thin layer of compact bone. A fractured surface will be more or less uneven and the trabeculæ of the cancellous tissue will open onto the line of fracture. The trabeculæ of an anomalous bone do not open onto any surface but are covered by a thin layer of compact tissue which shows as a thin continuous line in the X-ray plate. Anomalous bones are not necessarily bilateral, yet if an osseous anomaly of development is found in one side of the skeleton an X-ray of the same region on the opposite side of the body will almost invariably show a corresponding condition.

Treatment.—Reduction of luxations of either the radio-carpal or medio-carpal joints is accomplished by traction and counter-traction with direct pressure over the prominent displaced carpus. It is seldom that difficulty is experienced in correcting the displacement. There is rarely any tendency to recurrence of deformity in uncomplicated cases. Fracture luxation of the wrist may tend to recur if the radial fragment is large. Following reduction the wrist should be immobilized on a short ventral splint. The further conduct of the case will be considered under "After-treatment," page 292. Displacement is seldom pronounced in fractures of the carpal bones and when reduction is necessary it will usually consist of forcing prominent fragments back into position. Reduction of luxations of the carpal bones may be readily accomplished in some cases by direct pressure, while in other instances it may be impossible without operative intervention. In dorsal luxation of any bone of the carpus the wrist should be flexed until the displaced bone is "started" back into the position which it previously occupied. When the bone is once "started" the hand should be extended until it comes in line with the forearm, when traction and countertraction are exerted and the carpal bone driven home by direct pressure. In the reduction of ventral luxations the opposite manipulation is followed. The wrist is fully extended, the dislocated bone started back into position, the hand then brought to a straight line with the forearm and reduction completed. Following any fracture or luxation of the carpus immobilization is indicated.

Operative Treatment.—Operation is indicated in compound cases and in instances in which reduction cannot be effected by manipulation. Closed luxations at the wrist seldom call for operative measures. Recurrence of deformity in fracture-luxations of the radio-carpal joint may require fixation of the radial fragment. Displaced fragments of carpal bones or a completely luxated bone may require removal through incision. Old fractures or luxations of the carpal bones with restriction of motion due to mechanical interference from a luxated bone or displaced fragment, may require operation with removal of the obstructing bone or fragment.

After-Treatment.—Fixation of the wrist following fractures and luxations of the carpus is essential, yet early passive motion is equally necessary if the function of the part is to be fully restored. It is apparent that non-union of any one of the carpal bones would not offer any mechanical obstacle to the full restoration of function. Yet, on the other hand, it is a noteworthy fact that cases which are allowed free use of the wrist following the accident do not show the complete and rapid recovery seen in cases treated by proper immobilization and passive motion. Early unrestricted use of the wrist is followed by a chronic inflammation of the synovial surfaces which results in stiffening of the wrist. Prolonged immobilization without passive motion is followed by joint adhesions which are equally detrimental to function. The proper treatment consists in immobilization of the parts with early passive motion. Passive motion should be begun as soon as the traumatic reaction has subsided and should be repeated at intervals of three or four days until the splint is removed. At the end of three or four weeks all dressings may be dispensed with and the patient instructed to gradually increase the use of the wrist. Massage and hot applications are of value in hastening the restoration of function.

Prognosis.—Uncomplicated fractures and luxations of the carpus in young or middle aged persons are followed in most instances by at least a fair restoration of function. In elderly persons the wrist is likely to remain painful and to show more or less restriction of motion in spite of the most painstaking treatment. Compound fractures of the carpus, especially crushes, have a much more unfavorable prognosis. If infection follows in compound cases the chances of a stiff wrist are great, to say nothing of the possible loss of function in the fingers due to adhesions between the tendons and their sheaths. When function is restricted or painful as a result of the displacement of one of the carpal bones, the outlook is good, if the condition is corrected by operative measures.

CHAPTER XXI.

LUXATIONS OF THE CARPO-METACARPAL ARTICULATION.

Surgical Anatomy.—The articulation between the carpus and metacarpal bones is heavy and strong, and complete luxations of this joint are extremely rare. From a surgical standpoint the articulation may be divided into two parts: first, the articulation between the inner four metacarpals and the carpus, and second, the joint between the trapezium and first metacarpal. The articulations between the inner four metacarpals and the carpus are functionally one continuous joint. The synovial cavity extends from the second to the fifth joint and is not subdivided by the ligaments. The three inner carpal bones articulate with each other above the plane of this joint and the metacarpals below the joint articulate with each other by their lateral surfaces. The inner four metacarpal joints are arthrodial in type; the fifth joint is capable of a wider range of motion than the other three. The carpo-metacarpal joint of the thumb is one of reciprocal reception (saddle joint) and permits of motion in all directions except axial rotation. The articulation between the first metacarpal and the trapezium is surrounded by a capsule, is separated from the other carpo-metacarpal articulations and has its own synovial membrane. All five carpo-metacarpal articulations are known to have been luxated, and all except that of the little finger have been reported as isolated injuries. Dislocation may occur in one or more of the joints simultaneously, and a number of instances of luxation of all five articulations have been recorded. Luxation may occur in any direction but the most common forms are either forward or backward. The lateral support which the inner four metacarpals offer each other explains the rarity of lateral luxations. The carpo-metacarpal joint of the thumb is the most commonly luxated. More dislocations of this joint have been reported than of the other four carpo-metacarpal articulations combined. Backward luxations of the carpo-metacarpal joint of the thumb are by far the most common.

Forward luxations are extremely rare. Luxations of this joint are not infrequently complicated by fracture of either the trapezium or base of the first metacarpal or by luxation of the adjoining carpo-metacarpal joint of the index finger. Luxation of the carpo-metacarpal joint of the index finger is next in order of frequency and is more often displaced backward than forward. Luxations of the third, fourth and fifth carpo-metacarpal articulations are extremely rare. They may be either of the forward or backward type. Subluxations, especially of the backward type, are not as rare in the four inner metacarpals as in complete luxation. Divergent luxations have been reported in which some of the metacarpal bases have been displaced backward while others were luxated anteriorly. This form of dislocation, however, is extremely rare and can hardly be considered as a type. Severe crushing violence in this region may produce almost any type of fracture-luxation as in the carpus, and because of the superficial position of the bones is likely to be compound.

Symptoms.—In luxations of the carpo-metacarpal joint of the thumb there will be loss of function, shortening of the thumb and characteristic deformity. In the backward type the base of the first metacarpal will be unduly prominent on the dorsal aspect of the carpus, just below the end of the radius. In the ventral type the trapezium may be palpated and the base of the metacarpal forms a hard prominence beneath the thenar eminence. Various degrees of angular deformity may be present as well as the overriding displacement. The forward or backward displacement accompanying luxations of any or all of the inner four articulations can be appreciated without difficulty if the case is seen early. If the injury is not examined before the onset of the traumatic reaction the swelling may be so pronounced that the nature of the deformity is not apparent. The shortening of the fingers, however, will be a symptom which will be evident even though the balance of the deformity is obscured by swelling.

Diagnosis.—Luxation of any one of these joints should be recognized without difficulty if the case is seen early. When four or five of the metacarpals are dislocated simultaneously the traumatic reaction may be so severe that diagnosis is rendered difficult unless the patient is anesthetized or the X-ray resorted to. Fracture of either the carpals or metacarpals is not an uncommon complication and is recognized by the presence of crepitus. If doubt exists the

X-ray should be employed. In interpreting X-rays of this region the anomalies mentioned under the Surgical Anatomy of "Injuries to the Carpus" on page 283, should be kept in mind.

Treatment.—Reduction is usually accomplished without difficulty by traction, counter-traction and direct pressure on the displaced metacarpal base or bases. Luxation of the carpo-metacarpal of the thumb is more likely to give trouble in reduction than are the corresponding joints of the other fingers. If reduction cannot be effected by manipulation open reduction may be necessary. A tendency to the recurrence of deformity seldom occurs in any of these joints unless fracture complicates the luxation. Following reduction the wrist and hand (but not the fingers) should be immobilized on a short splint. The character of the splint is not essential as long as it fits the parts comfortably and effects immobilization.

Operative Treatment.—Operation is seldom indicated in the reduction of luxations of single joints. In luxations which cannot be reduced by manipulation the articulation should be exposed by a longitudinal incision and the displacement corrected by direct manipulation through the incision. Compound cases should be treated as described under "Treatment of Compound Fractures and Luxations" on page 789.

After-Treatment.—The after-care of these cases is practically the same as that already given under "Injuries to the Carpus" (page 292). Early passive motion is most important.

Prognosis.—The outlook in luxations of the carpo-metacarpal articulations is similar to that already given under "Injuries to the Carpus." Loss of function in the first carpo-metacarpal articulation will lead to difficulty in opposing the thumb against the fingers, and will constitute a serious handicap in the use of the hand. In compound cases the prognosis is much more unfavorable, especially in the presence of infection.

CHAPTER XXII.

FRACTURES OF THE METACARPALS.

Surgical Anatomy.—The structure of the metacarpals resembles that of other long bones with the exception of the ossification. The ossification of the inner four bones is the same. One center for the shaft and base, and one for the distal end or head. The center for the single epiphysis is first seen about the third year and joins the shaft during the twentieth. The metacarpal of the thumb has its single epiphysis located at the base. It begins to ossify during the third year and joins the shaft in the twentieth. Occasionally this bone has an additional epiphysis for the head

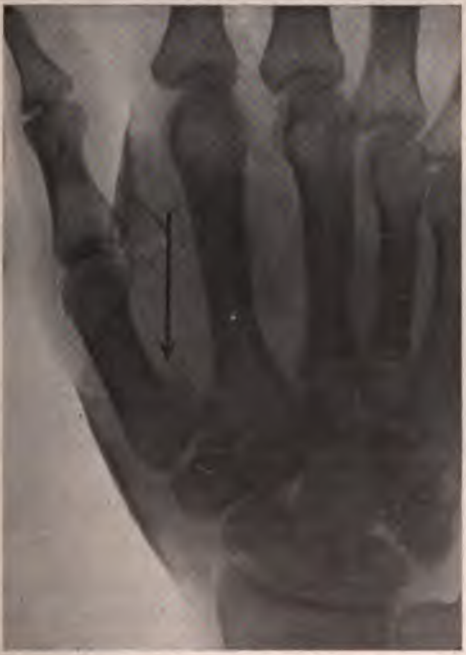

Fig. 422.—Fracture of the base of the first metacarpal entering the joint. Bennett's fracture.

which is visible at the seventh or eighth year. The first metacarpal may thus resemble both phalanx and metacarpal in its process of ossification. The positions of the epiphyseal cartilages are of importance in interpreting Röntgenograms of this region. The shaft of a metacarpal is composed of a tube of compact tissue, while the extremities are cancellated and enclosed in a thin layer of compact bone. This change in structure between the shafts and extremities accounts for the not uncommon impaction of the shaft into the head of the bone following a blow on the knuckle. Fracture of the metacarpal shafts usually results from direct violence, while fracture of the distal end is almost always caused by indirect violence. Fracture of the distal end is almost invariably produced in boxing or fighting. A "punch" is "landed" on some bony prominence such as the jaw or skull, and the head of the most prominent metacarpal is driven upward onto the shaft of the bone and also displaced slightly into the palm of the hand. This forward displacement is due largely to the normal curvature of the shaft and to the fact that the palmar aspect of the head is not as

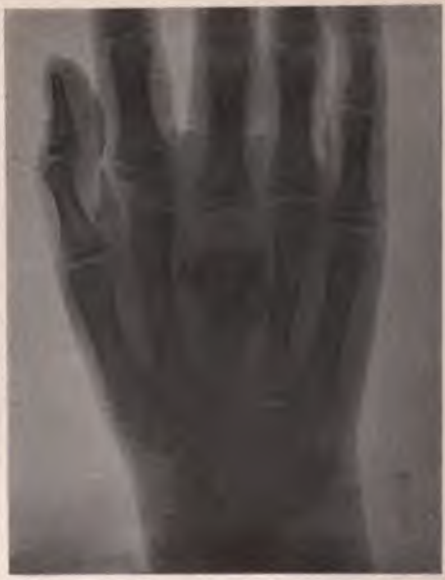

Fig. 423.—Gun-shot fracture of the third metacarpal. This plate shows the epiphysis of the hand at thirteen years of age. Note the single epiphyses of the phalanges situated at the proximal ends of the bones. The epiphyses of the metacarpals are situated at the distal ends of the bones with the exception of the first metacarpal.

well supported as the dorsal. When the hand is tightly closed in a fist the heads of the metacarpals form the prominence of the metacarpo-phalangeal knuckles and the impact of violence sustained on these knuckles is the most common cause of fracture. Fracture is not uncommon in any of the metacarpals but is most frequently seen in the third and fourth. The most usual site of fracture in the inner four bones is just above the head while the most common seat of the break in the metacarpal of the thumb is through the base and involving the articular surface. Fracture of the base of the first metacarpal is known as Bennett's fracture. The clinical appearance and X-ray findings in this lesion are well shown in Figs. 422 to 424. The first metacarpal is isolated and can be palpated without difficulty, while the posterior surfaces of the inner four bones are subcutaneous and can be palpated from end to end unless the hand is markedly swollen. A number of metacarpals may be fractured simultaneously but it is much more common to see an isolated fracture of one of them a short distance above the head.

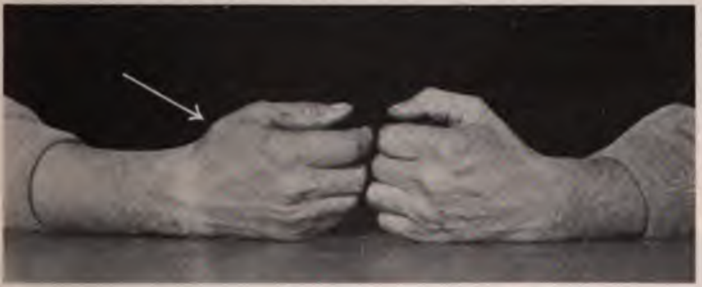

Fig. 424.—Bennett's fracture in the right hand. Note the abnormal prominence at the base of the first metacarpal. Picture taken a few minutes following the accident.

Symptoms.—Pain, swelling, tenderness and loss of function are constant. The disturbance in function accompanying fracture of one or more of the metacarpals usually consists in an inability to completely flex the fingers. This is due to pain, swelling and the fact that the head of the fractured metacarpal is displaced so that there is a mechanical interference with complete flexion of the first phalanx. The deformity is usually characteristic (see Figs. 428 to 433). The head of the injured bone is usually displaced into the palm and when the fingers are flexed the corresponding knuckle will be found at a lower level than normal. It will often be pos-fractures in this region. Luxation of this bone is quite rare. A number of cases of subluxation of the head of the os magnum have been reported. They have been accompanied by an undue prominence on the dorsal aspect of the carpus, especially during complete dorsal flexion of the wrist. The loss of function produced by these subluxations is surprisingly slight.

Fractures of the trapezium and *trapezoid* are extremely rare except in severe crushes of this region. They may occur, however, and are accompanied by crepitus and mobility at the base of the first or second metacarpal, as the case may be. Crepitus in the region of the base of the first metacarpal is almost always caused by Bennett's fracture and rarely by fracture of the trapezium (see "Fractures of the Metacarpals," page 297). Luxations of either of these bones is extremely rare, and since only dorsal luxations have been reported, the prominence of the displaced bone may be expected on the dorsal aspect of the carpus.

Fracture of the unciform is practically unknown except as a complication of luxation or in severe crushing injuries of the carpus. The process has been reported as broken off accompanying luxation.

Diagnosis.—Theoretically the diagnosis of fractures and luxations of these bones should be easy but the difficulty of ascertaining the exact nature of these injuries is shown by the frequency with which the diagnosis is changed after the X-ray has been employed. The appearance of the wrist is so characteristic in luxations of the radio ulnar joint that it would seem almost impossible to fail in recognizing the nature of the injury. It is a well known fact, however, that Colles' fracture is frequently mistaken for dislocation of the wrist. One who has never seen a dislocated wrist should hesitate in pronouncing an injury of this region a dislocation unles the diagnosis has been confirmed by an X-ray examination. (See Figs. 378 and 379.) Medio-carpal luxations are extremely rare and it will be safer to make only a tentative diagnosis pending the report on the X-ray, even though one feel reasonably certain of the condition.

The size of the carpal bones and their compact arrangement are such that accurate diagnoses of isolated lesions of these bones are almost impossible. The important point to be determined by inspection and palpation is whether or not fracture or luxation exists. The treatment of the different traumatic lesions in this no excuse for this mistake if the parts are carefully examined following the injury. The deformity is usually so characteristic and pronounced that the diagnosis can be made by inspection alone unless the swelling is exceptionally pronounced. Bennett's fracture is most frequently mistaken for a sprain or subluxation of the articulation between the first metacarpal and trapezium. Manipulation of the thumb will almost invariably elicit crepitus and disclose the nature of the injury without the aid of the X-ray.

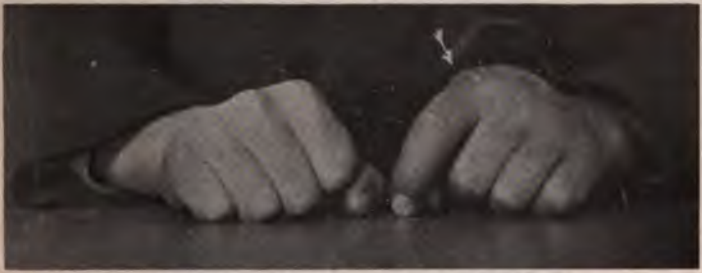

Fig. 428.—Fracture of the left index metacarpal behind the head of the bone with dropping of the knuckle. Note the alignment of the knuckles of both hands and how the index knuckle of the patient's left hand is displaced forward toward the palm of the hand. Condition about twelve hours old and the result of "punching" someone. Motion and crepitus present after the slight impaction is broken up.

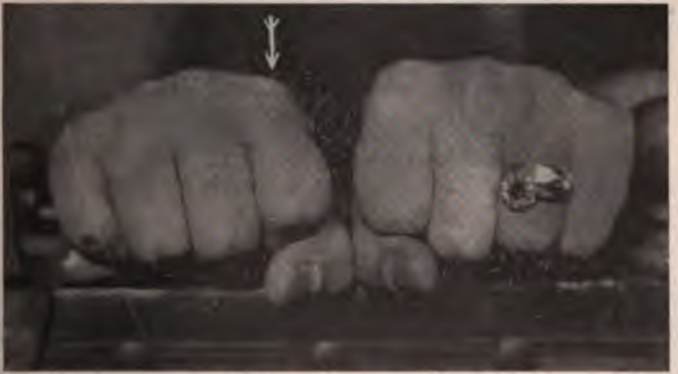

Fig. 429.—Fracture of right index metacarpal of about four years' standing. Deformity has been allowed to go uncorrected, knuckle is "dropped" and complete flexion of the index finger impossible. Prominence of metacarpal head may be felt in the palm. The fifth metacarpal of the same hand was fractured about one month ago and the dressings (similar to those shown in Figs. 434, 435, 436 and 437) have just been removed. Note how the knuckle of the little finger is up in line with the other knuckles. Swelling has not yet entirely subsided and the outline of this knuckle is not as sharp as the same knuckle of the opposite hand.

Treatment.—Reduction of the usual deformity is accomplished by traction on the finger corresponding to the injured metacarpal. The ligaments connecting the base of the first phalanx with the head of the metacarpal are thus employed in pulling the distal fragment back into position. During this manipulation the upper fragment is to be steadied by the thumb and fingers of the opposite hand. Reduction is, as a rule, easily accomplished but the deformity recurs as soon as the parts are released. The dressings, therefore, must be depended upon to retain the fragments in posi-

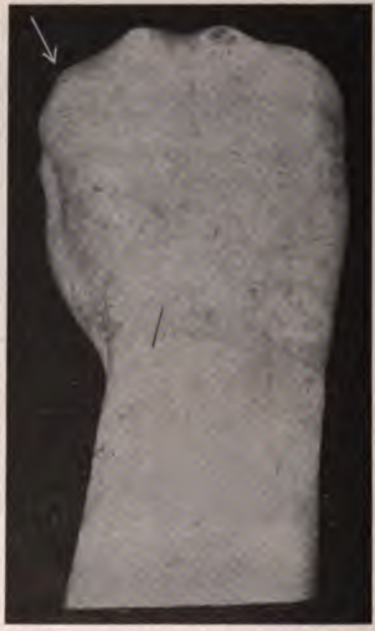

Fig. 430.—Pronounced "falling" of the index knuckle due to fracture of the second metacarpal near its distal end.

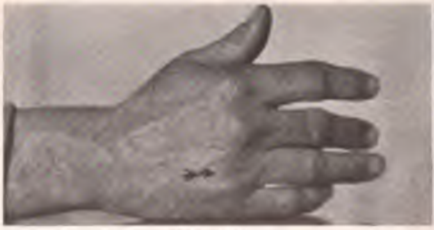

Fig. 431.

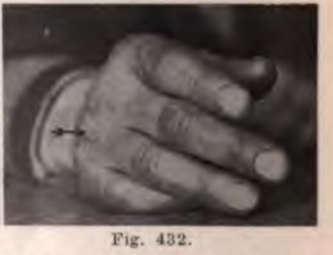

Fig. 432.

Figs. 431 and 432.—Two views of a recent fracture of the fourth metacarpal near its distal end. Note the slight "falling" (ventral displacement) of the fourth knuckle. Photographs taken a few minutes following injury, which accounts for the absence of swelling.

tion during the process of repair. It will usually be possible to prevent overriding displacement by an engagement of the serrated fractured surfaces, but angular deformity can only be avoided by proper dressings. The method of fixation which will meet the requirements in the greatest number of cases is shown in Figs. 434 to 437. Following reduction a roller bandage is placed in the palm, the fingers flexed over it and secured in position by two strips of adhesive plaster. A machine rolled bandage such as put out by the supply houses should be used to secure the proper firmness. A roller four inches wide by ten yards in length is most appropriate. The diameter of this roll, however, is a little too great for the average size hand and should be reduced by removing the outer layers of the bandage until it is small enough to allow the first row of phalanges to be flexed to a right angle with the metacarpals as shown in Fig. 434. This position allows the head of the broken bone to be "raised" into line with the other knuckles without making upward pressure on the lower fragment. After the roller has been placed in position diagonal strips of adhesive are used as shown in Fig. 436 to raise the injured knuckle. The entire hand is then covered with a bandage and carried in a sling.

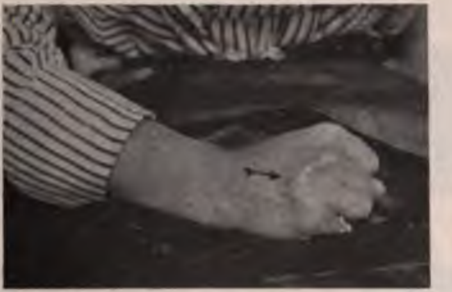

Fig. 433.—Fracture of fourth metacarpal about twenty-five years ago (during childhood). Injury to the epiphyseal cartilage with subsequent arrest in growth accounts, in part, for the pronounced deformity.

In some instances the fracture is situated in the shaft and oblique enough to prevent a firm engagement of the broken surfaces. Under such circumstances the roller bandage will not correct the tendency to overriding deformity and continuous traction will be necessary to keep the fragments in proper relation. A narrow splint is properly padded and secured to the palm of the hand by means of strips of adhesive plaster. This splint should extend about three inches beyond the end of the corresponding finger. Extension is then secured by means of light rubber tubing; one end of the tubing is attached to the end of the splint while the other is attached to the finger by means of strips of adhesive plaster.

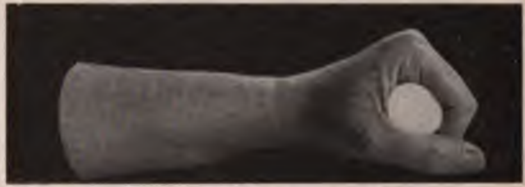

Fig. 434.—Roller bandage of appropriate size placed in hand.

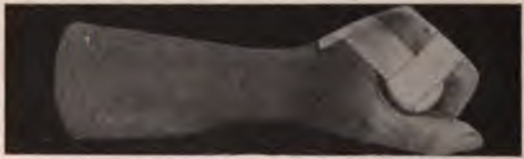

Fig. 435.—Same secured in position by strips of adhesive.

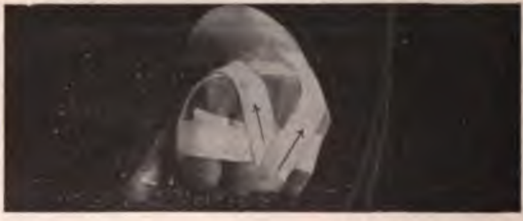

Fig. 436.—Strips of adhesive used to correct deformity and raise the knuckle of the ring finger.

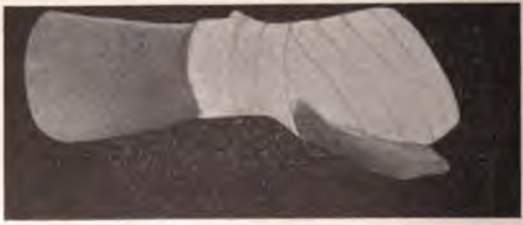

Fig. 437.—Hand bandaged and dressing complete.

Fractures of any of the four inner metacarpals may be treated by means of two splints (dorsal and palmar) properly padded, though they are not as reliable and secure as the roller bandage, unless made of plaster of Paris. If plaster splints are used they should be applied with due regard for the nature and tendency of the deformity. Eight or ten thicknesses of gauze should be used and the material cut so that one splint will cover the dorsal aspect of the hand and wrist while the other covers the palm and ventral surface of the wrist. These two splints are then soaked in plaster cream, wrung out and rapidly secured in position by a roller bandage. While the plaster is setting the surgeon should grasp the hand in such a manner that pressure will be made in the palm opposite the displaced head, while counter pressure is exerted over the uninjured metacarpals on the dorsum of the hand. This raises the injured knuckle and the pressure exerted by the surgeon's fingers is continued by the splints after the plaster has set. The splints should be removed as soon as the plaster has hardened sufficiently to maintain its proper form, and reapplied only after the plaster has thoroughly set and dried out. Placing the splints on a radiator or in the sun will hasten the process.

Fracture of the shaft of the first metacarpal is most satisfactorily treated by means of the splint shown in Fig. 440. The curves of the thumb and thenar eminence are such that an accurately fitting splint can be had only by using a material such as plaster which can be moulded. Bennett's fracture often requires no splint whatever. It is frequently possible to correct the lateral and backward displacement of the base of the bone by means of strips of adhesive plaster exerting pressure in the direction shown in Fig. 427. With the deformity thus corrected the thumb is immobilized with adhesive strapping similar to that employed in the treatment of a sprain.

Operative Treatment.—Operation is almost never indicated in recent fractures of the metacarpals unless the condition is compound. When the fracture is open it should be treated according to the principles laid down under "The Treatment of Compound Fractures and Luxations" on page 789. In old cases with deformity the patient may suffer considerable loss of function with persistent pain or tenderness in the palm opposite the displaced head. If these symptoms are pronounced and interfere with work operation is indicated. The incision is best made on the dorsal aspect of the hand and should avoid the extensor tendon of the corresponding finger. With the metacarpal exposed the bone is divided at the original site of fracture and the knuckle raised. The wound is then closed and the condition treated as a recent fracture with the deformity fully corrected.

After-Treatment.—The after-care of these cases calls for frequent inspection of the dressings which are sure to become lax or slip no matter how well applied. As soon as the dressing becomes loose the deformity recurs and thus a deformed hand may follow even though the original reduction was perfect. Pressure points may show erosion during the after-treatment and call for treatment. If the roller bandage dressing is used the knuckles under the adhesive straps may become irritated and require relief from pressure. With the slightest signs of irritation the dressing should be reapplied and bits of cotton placed between the adhesive plaster and skin. The dorsum of the hand should be carefully watched for backward bowing of the shaft of the fractured metacarpal which may develop at any time. Direct pressure on the shaft may be necessary and is had by means of pads and adhesive straps. Backward bowing is not likely to occur if the first phalanges are fixed at a right angle with the metacarpals, as previously mentioned under "Treatment." Immobilization may be discontinued at the end of three weeks but the hand should not be subjected to strain for another two weeks as deformity may recur. Heavy work should be avoided for two months or more.

Prognosis.—In an uncomplicated fracture of one of the metacarpals with correction of the deformity there should be complete restoration of function. If the deformity is not corrected there will be incomplete flexion of the corresponding finger, a weakened grip and more or less pain and tenderness in the palm of the hand opposite the displaced head. These symptoms will be present according to the degree of deformity.

CHAPTER XXIII.

FRACTURES OF THE FINGERS.

Surgical Anatomy.—The phalanges are practically subcutaneous throughout and fractures of these bones are, as a rule, detected without difficulty. The fleshy pads on the palmar aspect of the fingers are comparatively thick, and palpation on this side of the digit is less satisfactory than elsewhere. The quadrilateral expanded bases may be palpated without difficulty. The internal structure of the phalanges is similar to that found in other long bones. The extremities are composed of cancellous tissue covered by a thin layer of compact bone, while the shafts consist of tubes of heavy compact tissue. Accordingly fractures occurring in the extremities are more prone to show comminution and crushing of cancellous tissues, while breaks through the shafts are usually clean cut and never impacted.

The dorsal aspect of each finger, from the head of the metacarpal to the base of the terminal phalanx, is in contact with the extensor tendon. The anterior aspect of each digit is in relation with the flexor tendons. The tendons of the flexor sublimis digitorum are inserted into the sides of each middle phalanx, while the tendons of the flexor profundus digitorum are inserted into the bases of the terminal phalanges. These tendons and the synovial sheaths enclosing them are of considerable importance in the treatment of fractures of the fingers. Prolonged immobilization, following the traumatic inflammation which accompanies fractures, is likely to give rise to adhesions between these tendons and their sheaths; such adhesions limit motion after recovery takes place.

Epiphyseal separations are rare in the fingers though they are occasionally seen. Each phalanx is ossified by two centers, one for the base and one for the head and shaft. The bases of the proximal row of phalanges begin to ossify during the third or fourth year and join the shafts at about the eighteenth year. The shafts of all the phalanges show signs of ossification soon after birth.

The prominences of the knuckles do not correspond to the planes of the joint but are formed by the heads of the bones above the articulation. The digital vessels and nerves run on either side of, and a little ventral to, the lateral borders of the phalanges.

The use to which the hands are put in the different trades and in various types of labor exposes the fingers to all kinds of direct violence. This is particularly true of those working about machinery. The fact that the phalanges are subcutaneous results in a high proportion of compound fractures and luxations, even though the skin covering these parts is heavy and strong. Fractures of the fingers, especially those produced by machinery, are often accompanied by severe and extensive laceration and bruising of the overlying soft tissues.

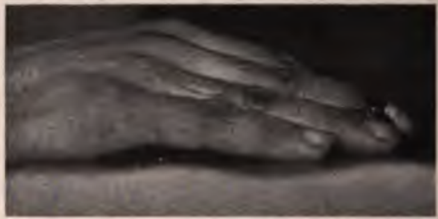

Fig. 438.—Compound fracture of the base of the terminal phalanx of the middle finger with backward displacement and tearing of nail from its bed.

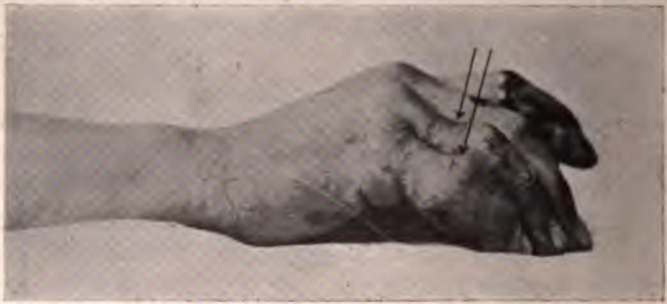

Fig. 439.—Severe compound fractures of the proximal phalanges of the fourth and fifth fingers. Wounds on ventral aspect of fingers. Injury sustained in machine accident.

Symptoms.—Local pain, loss of function and swelling of the injured finger are almost invariably present. Crepitus and abnormal mobility can usually be elicited without difficulty. When the fracture is near the end of the phalanx the point of preternatural mobility may be difficult to recognize because of the proximity of the joint. Crepitus is not as easily elicited when the break is near the end of the bone. Deformity varies considerably; it may be pronounced enough to establish the nature of the injury by inspection alone, or it may be absent. A type of injury known as "base-ball finger" consists of fracture of the terminal phalanx with impaction, as shown by the X-ray, but the symptoms do not conform to the symptoms accompanying the usual fracture. The injury is produced by being struck on the end of the finger by a base-ball. Following the trauma the finger is painful and tender and somewhat swollen, but mobility and crepitus are usually absent. There is a slight deformity which can not be recognized until the swelling subsides. These fractures are often overlooked if the case is not examined with the Röntgen ray. Recovery is usually slow, the finger remaining tender and painful for weeks and even months.

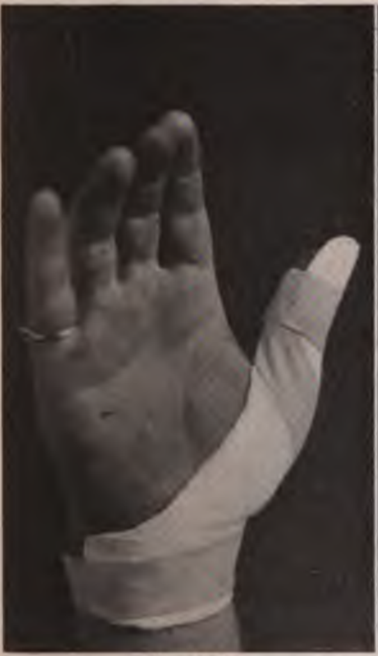

Fig. 440.

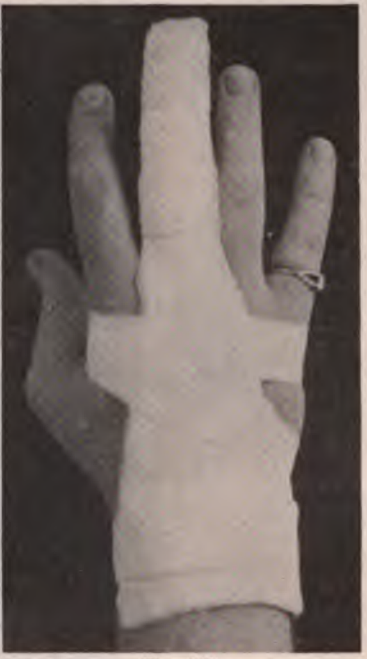

Fig. 441.

Fig. 440.—Plaster splint applied to thumb. The curves of the thumb from wrist to thumb-tip are such that it is difficult to obtain a good fit with any other form of splint.

Fig. 441.—Plaster splint applied to dorsal surface of middle finger and back of hand. Secured in place by means of strips of adhesive.

Diagnosis.—Fractures of the fingers can be recognized without difficulty if the parts are carefully examined following the injury. When deformity is present there may be a tendency to recurrence of displacement following reduction but this is seldom the case in dislocations. The finger nail renders the terminal phalanx difficult to palpate, and the typical base-ball fracture cannot ordinarily be recognized in this way. The X-ray should be used when there is doubt.

Treatment.—The proper treatment of fractures of the fingers is of greater importance than would at first appear since there is only a small proportion of men who do not depend, at least partially, on their hands for a livelihood. A crippled hand often means impaired earning capacity.

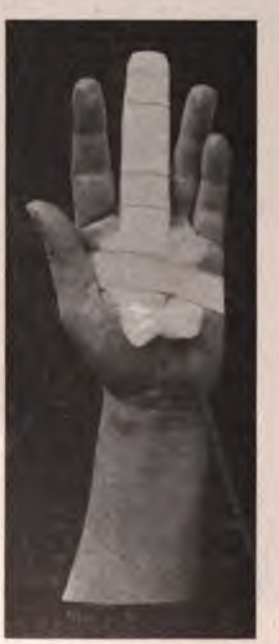

Fig. 442.—Splint of cigar-box wood padded, bandaged and placed in position to immobilize middle finger. Note the cotton in palm of hand.

When there is deformity it should be corrected at the earliest possible moment and the finger immobilized. In fractures of the phalanges it has been customary to immobilize the injured finger in a position of complete extension. A position of slight flexion, however, will be found much more comfortable since the flexor and extensor tendons more nearly balance each other in this attitude. A straight palmar splint may be used as shown in Fig. 442, but the padding should be so arranged that the surface coming in contact with the finger will present a slight curve. The splint is secured in position with strips of adhesive plaster. If the digit is immobilized soon after the accident the dressings should not be too tightly placed, as otherwise strangulation may take place when the finger swells. Copper wire may be used as a splint, but when this is done padding should first be placed about the finger. The most perfect splint is made with plaster of Paris and gauze or crinoline. (See Figs. 440 and 441.) This form of splint fits the parts perfectly because it is moulded to them and the finger may be placed in any degree of flexion according to the needs of the case. When the fracture is compound anteriorly the splint may be placed on the dorsal aspect of the hand and will hold the parts securely.

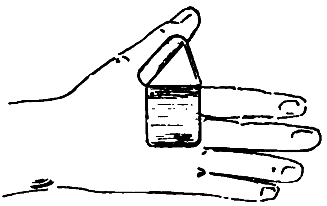

Fig. 443.

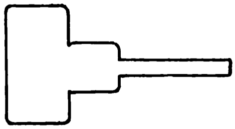

Fig. 444.

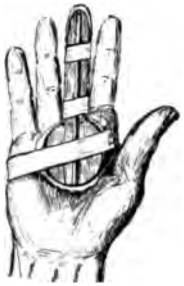

Fig. 445.

Fig. 443.—The Goldthwaite tin, thumb splint in position. A layer of cotton should be used to keep the metal from coming in contact with the skin.

Fig. 444.—Pattern from which the Goldthwaite splint is made.

Fig. 445.—The finger splint padded and held in position by strips of adhesive.

Compound fractures should be treated according to the principles laid down under the heading of "Treatment of Compound Fractures and Luxations" on page 789. Ethereal antiseptic soap will be found of considerable advantage in the removal of dirt and grease from the hands of mechanics and machinists preparatory to washing the wound with salt solution.

Operative Treatment.—Operation is rarely indicated in fractures of the fingers except in compound cases. The wound should be treated according to the principles set forth on page 789. Lacerated tissues should be trimmed away and the wound thoroughly irrigated before the edges are approximated. If the fracture is produced by some cutting instrument and the tendons divided they should be repaired before the wound is closed. In severe crushes of the fingers amputation may be necessary.

After-Treatment.—During the after-treatment the finger should be carefully watched to keep the dressings properly adjusted and to prevent recurrence of deformity. If the trauma accompanying the fracture has been great it may be best to postpone the application of splints until the swelling has subsided. During this time the finger is immobilized by surrounding the digit with cotton and bandaging the adjoining fingers to it. The ice cap will tend to control the traumatic reaction. Fixation should be maintained for a period of three weeks in uncomplicated cases, but guarded passive motion begun at the end of ten days will be of the greatest advantage in preventing adhesions within the joints and between the tendons and their sheaths. In compound cases the greatest care should be exercised to prevent infection and suppuration of the wound following the initial treatment. If infection becomes established necrosis of bone and non-union are likely to follow. If necrotic bone is present it should be removed as soon as possible

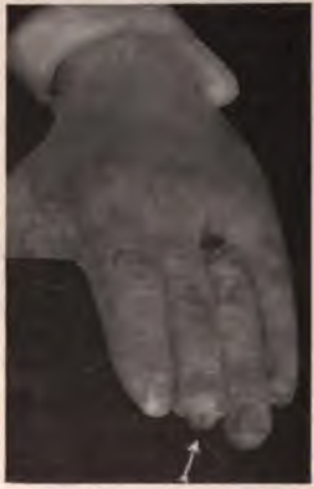

Fig. 446.—The result of saving too much of the finger in crushes of the terminal phalanx. The base of the nail bed has been left which produces the heavy claw-nail which is a continual source of annoyance.

and an attempt made to convert the suppurating sinus into a healthy wound. If union is not present at the end of four or five weeks it is probable that it will never occur especially without surgical intervention. Under these circumstances it may be best to amputate. In crushes of the terminal phalanx the inadvisability of attempting to save the base of the nail bed is shown in Fig. 446. As shown in this case the nail forms a heavy, deformed annoying protuberance.

Prognosis.—The outlook in fractures of the fingers depends entirely on the severity of the injury. In simple cases recovery should be complete while in severe crushes it may be impossible to avoid amputation, to say nothing of obtaining union in the fractured phalanx. The accompanying injury sustained by the soft tissues is a most important element.

CHAPTER XXIV.

DISLOCATIONS OF THE FINGERS.

Surgical Anatomy.—The articulations between the metacarpal bones and the proximal row of phalanges are condyloid in type and permit of flexion, extension, adduction, abduction and circumduction. A variable amount of hyperextension is normal in these joints and varies in different individuals. These joints are held together by two lateral and one ventral ligament. The place of the posterior ligament is taken by the extensor tendon which crosses the articulation. The interphalangeal articulations are typical hinge joints and permit only of flexion and extension. A greater degree of flexion is possible in the proximal interphalangeal joint than in the distal articulation, though in the latter a greater degree of hyperextension is usually possible. The ligaments resemble those of the metacarpo-phalangeal joints; there are two lateral and one ventral ligament, the function of the posterior ligament being performed by the extensor tendon. The metacarpo-phalangeal articulations of the thumb and forefinger are more often dislocated than the three corresponding joints of the middle, ring and little fingers taken together. The displacement may be backward, forward, or lateral, and there may be overriding as well as angular deformity, and not infrequently the condition is compound. The anterior ligament is heavy and rigid and in backward luxations it is usually torn away from the metacarpal bone and may become interposed between the bones and offer obstruction to reduction. Backward luxation of the metacarpo-phalangeal articulation of the thumb is not an uncommon injury, and occasionally offers considerable resistance to reduction. This is due to the interposition of the anterior ligament and is probably not the result of the metacarpal head becoming caught between the tendons of the flexors of the thumb, as is commonly thought. Any of these luxations may be complete or incomplete according to the extent to which the phalanx has been displaced. Luxations of the interphalangeal joints are similar to those occurring between the metacarpals and proximal row of phalanges. The types of displacements are the same and the mechanism which obtains is similar.

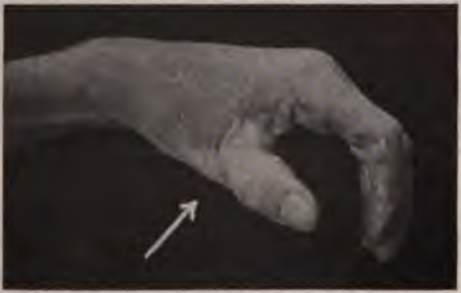

Fig. 447.—Dislocation of the thumb. Common form.

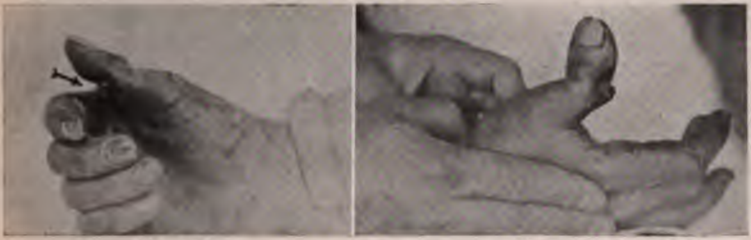

Fig. 448. Fig. 449.

Figs. 448 and 449.—Ventral and dorsal views of a compound dislocation of the terminal phalanx of the thumb. When an articular surface is exposed as this one is it should be thoroughly cleansed before reduction. (See "Operative Treatment of Compound Fractures and Luxations," Chapter LXI.)

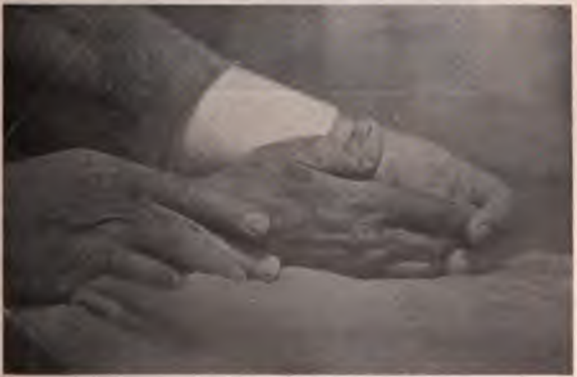

Fig. 450.—Old outward dislocation of thumb which was never reduced. Picture taken years following injury.

Diagnosis.—The recognition of these luxations is too easy to require description. The patient will almost invariably diagnose

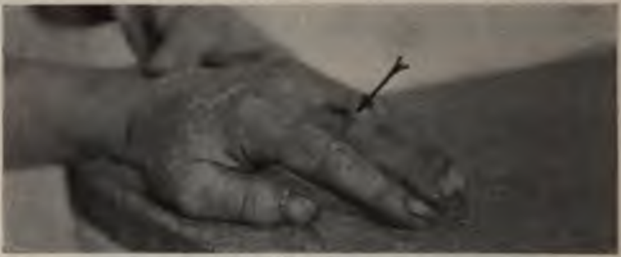

Fig. 451.

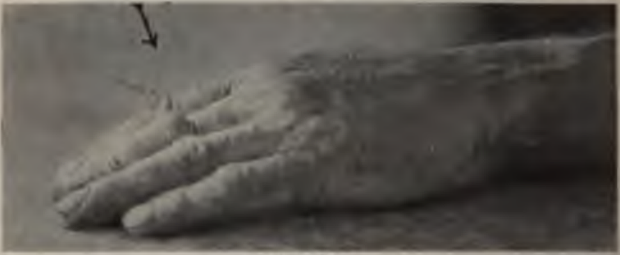

Fig. 452.

Figs. 451 and 452.—Recent backward dislocation of the second phalanx of the middle finger the result of a twisting strain. Base of the second phalanx lies behind the head of the first phalanx. Reduction easily accomplished by traction and counter-traction followed by flexion.

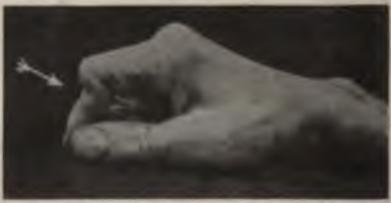

Fig. 453.—Ventral dislocation of second knuckle. Easily reduced.

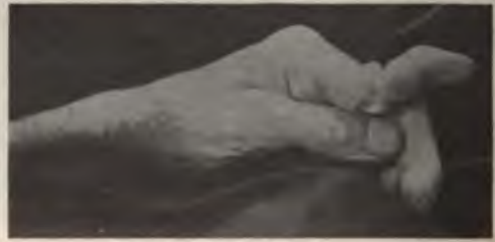

Fig. 454.—Backward dislocation of left index finger. The head of the first phalanx projects through the skin. This type of dislocation almost invariably becomes compound by tearing of the skin on the ventral aspect of the finger opposite the joint.

the nature of the injury before the surgeon sees him. Complicating fracture of the base of the distal phalanx is, however, occasionally overlooked.

Symptoms.—The injured finger is immediately thrown out of function and the accompanying pain is usually severe. The deformity is apparent and characteristic and varies according to the nature and direction of the luxation. The accompanying illustrations will serve to convey an idea of the appearance of these joints immediately following the different forms of dislocation. (See Figs. 447 to 455.)

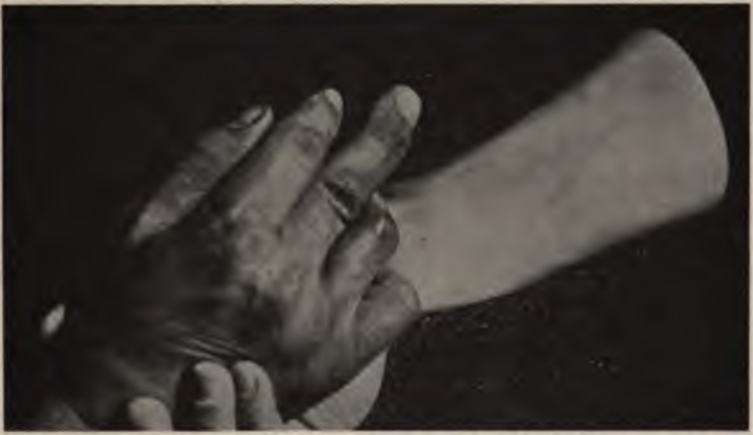

Fig. 455.—Backward luxation of the second joint of the middle finger. Dislocation rendered compound by wound on ventral surface of finger opposite the joint. Wound similar to that seen in Fig. 454.

Treatment.—In simple cases reduction should be effected as soon as the case is seen. In compound luxations the displacement should not be corrected until the wound and exposed articular or synovial surfaces have been thoroughly cleaned and irrigated with salt solution, as will be described under the heading of "Treatment of Compound Fractures and Luxations" on page 789. The manipulations employed in reduction vary with the type of displacement and consist of sliding the base of the displaced phalanx back onto the head of the proximal bone. In a complete luxation with overriding deformity traction and counter-traction may prove inefficient and when such is the case the angular deformity should be increased until the edge of the base of the distal bone is started onto the head of the proximal bone, whether it be metacarpal or phalanx. The principles involved are similar to those employed in reducing fractures of the bones of the forearm where the fractured surfaces are engaged before the angular deformity is corrected. If the surgeon appreciates the conformation of the articular surfaces entering into the joint and the nature of the displacement there should be little difficulty in accomplishing reduction in uncomplicated cases.

Operative Treatment.—Operative treatment is indicated in compound cases and in instances in which some tissue, such as the anterior ligament, prevents reduction by manipulation. In compound cases the wound usually consists of a transverse tear on the ventral aspect of the joint and it is of the greatest importance that this wound be thoroughly cleansed and irrigated before the luxation is reduced. If infection follows a compound luxation it is probable that motion will be lost in the finger as a result of adhesions within the joints and between the tendons and their synovial sheaths. (See "Treatment of Compound Fractures and Luxations," page 789.)

After-Treatment.—Following reduction the injured articulation should be put at rest to allow healing of the torn ligaments. Early passive motion, however, is essential to the subsequent restoration of function. A satisfactory plan is to treat the injured member in a position of extension for the first three or four days and then to remove the dressing, flex the finger to break up forming adhesions, and immobilize it in this position for a similar period. These periods of flexion and extension are repeated until the after-treatment is complete. Thus, when adhesions are broken up within the joint or in the tendon sheaths and the position of the finger changed, the denuded synovial surfaces no longer remain opposed and the chances of the adhesions reforming are reduced. A straight splint may be used for the extended position and a roller bandage, such as is used in the treatment of fractures of the metacarpals (see page 304), may be used to immobilize the finger in flexion. Healing of the torn ligaments should be sufficiently far advanced at the end of two weeks to allow guarded use of the injured finger. In infected cases it may be quite difficult or even impossible to reëstablish motion after the wound has healed, and if the infection is severe it may necessitate multiple incisions for the evacuation of pus along the course of the synovial sheaths and in the tissues surrounding them.

Prognosis.—In simple cases restoration of function should be complete with proper treatment although a small degree of flexion may be permanently lost. In compound cases followed by infection, the prognosis will depend entirely on the virulence of the invading organism, the resistance of the patient and the treatment he receives. A serviceable joint may follow in a compound infected case, but the chances of a stiff finger are great and the patient should be made to appreciate this fact early in the after-treatment. If the infection is severe amputation may be necessary.

PART II.

HEAD AND TRUNK.

CHAPTER XXV.

FRACTURES OF THE NOSE.

Surgical Anatomy.—The bony framework of the nose comprises not only the two nasal bones, but also the nasal processes of the superior maxillæ, the bony septum and the nasal spine of the frontal. The nasal bones consist of two small, oblong, quadrilateral bones situated at the bridge of the nose. These bones articulate laterally with the processes of the superior maxillæ, above with the frontal (at the nasion) and in the median plane with each other. The two nasal bones meet in the median line and rest upon the spine of the frontal in much the same manner as the rafters of a roof rest upon the king-beam. This nasal spine is, in turn, backed up by the vertical plate of the ethmoid. This continuity of bony tissue, from the nasal bone to the christa galli, explains the possibility of a blow on the nose displacing the ver-

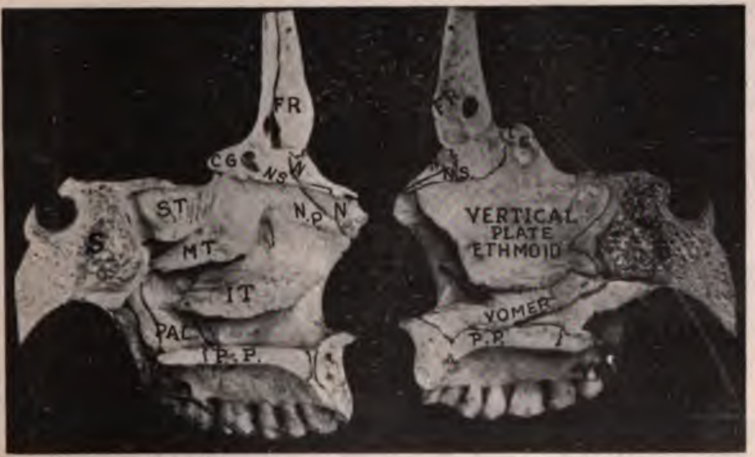

Fig. 456. Fig. 457.

Figs. 456 and 457.—Sagittal section through the nasal cavity. *F. R.*, Vertical plate of frontal; *N.*, Nasal bone; *N. S.*, Nasal spine; *N. P.*, nasal process of superior maxilla; *C. G.*, Crista Galli; *S. T.*, Superior turbinate; *M. T.*, Middle turbinate; *I. T.*, Inferior turbinate; *S.*, Body of sphenoid; *Pal.*, Palate bone; *P. P.*, Palatal process of superior maxilla.

tical plate of the ethmoid upward into the anterior fossa of the skull. In young subjects the articulations in the bony framework of the nose are distinct and contain more or less intersutural tissue, but in old age the sutures are ossified and the different bones become continuous. It is therefore evident that in the aged a greater amount of the trauma of the nose injuries is transmitted to the vertical plate of the ethmoid and septal complications are more common.

The lower half of the nasal bone is thinner and more friable than the upper half; the inferior border is sharp and has attached to it the upper lateral cartilages of the nose. In the less severe cases fracture is limited to the lower portion of the nasal bones because of the more exposed position and weaker construction.

The deep surface of the nasal bones is covered by mucous membrane which is commonly lacerated in fracture with displacement, and hence fractures of the nasal bones, which are usually considered simple (and are simple as far as the skin is concerned) are in reality rendered compound by laceration of the mucous lining on the deep surface.

The bony septum is composed of the vertical plate of the ethmoid above and the vomer below (see Fig. 457).

The angular interval between the ethmoid and the vomer is filled in by the cartilaginous septum. This cartilaginous septum articulates with the antero-inferior border of the vertical plate of the ethmoid and is continued into the vomer below. The junction of the cartilaginous septum with the anterior border of the vomer is peculiar because of the unusual manner in which the vomer is ossified. The ossification of the vomer begins in a single center and spreads in such a manner that two lateral plates of bone result, with a median layer of cartilage between them, which is continuous anteriorly with the quadrangular septal cartilage of the nose. Union between the two lateral plates of bone does not take place until after puberty. This peculiar arrangement results in the articulation between the vomer and the cartilage being stronger than the upper articulation between the ethmoid and the same cartilage. These anatomical points, together with the fact that the trauma is more directly transmitted to the upper part of the septum, account for the more frequent displacement taking place between the ethmoid and the quadrangular cartilage in youth. Unless the interior of the nose is carefully inspected early in the treatment, septal displacements may go unrecognized during the time that treatment would be most efficient.

The angular artery and vein (continuations of the facial vessels) are found running in a nearly vertical direction behind and lateral to the nasal bones, in which position they may give rise to troublesome hemorrhage when injured in severe compound fracture of the nose.

The nasal nerve, a branch of the ophthalmic division of the trifacial, runs longitudinally on the internal surface of the nasal bone after having passed from the orbit to the nasal cavity by way of the anterior ethmoidal foramen and nasal slit.

The upper portion of the vertical plate of the ethmoid is grooved for the passage of the ethmoidal nerves from the Schneiderian membrane to the olfactory bulb. The nasal nerve is, strictly speaking, a nerve of sensation, while the olfactory nerves have to do with the sense of smell; the juxtaposition of these nerves with the bones involved accounts for the frequent disturbances of smell and sensation following fractures in this region.

The mucous membrane of the nose is highly vascular, and in cases where a large vessel is lacerated we may experience considerable difficulty in controlling hemorrhage.

Etiology.—Fractures of the nasal bones and adjoining bony structures are the result of direct violence, such as blows on the face, falls and trauma sustained by various means. Fractures of the nasal bones constitute between four and five percent of all fractures. The injury is most commonly seen as the result of brawls.

Symptoms.—The prominent symptoms of fracture of the nose are deformity, mobility and crepitus. Swelling of the soft parts rapidly follows the trauma and epistaxis is practically constant and appears immediately following the injury. There is more or less obstruction to nasal respiration, depending upon the inward displacement of the fragments, the swelling of the mucous membrane and the accumulation of clotted blood within the nasal cavities. The more extensive the region involved by fracture and the more pronounced the trauma, the greater the frequency of pronounced nasal obstruction. In severe cases where the fracture extends well backward involving the nasal canal, in the nasal process of the superior maxilla, we may have obstruction of the nasal duct with consequent lachrymation of the affected side. Occasionally we have emphysema of the eyelids and face as a result of air having been forced from the nasal passages into the sub-

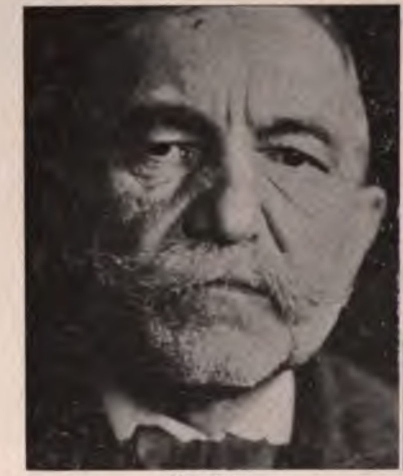

Fig. 458.

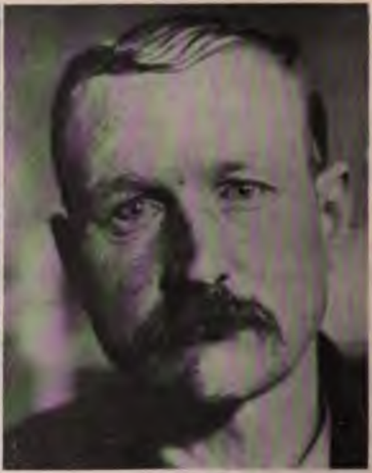

Fig. 459.

Fig. 458.—Old fracture of nasal bones with lateral displacement.
Fig. 459.—Old fracture of nasal bones with lateral displacement.

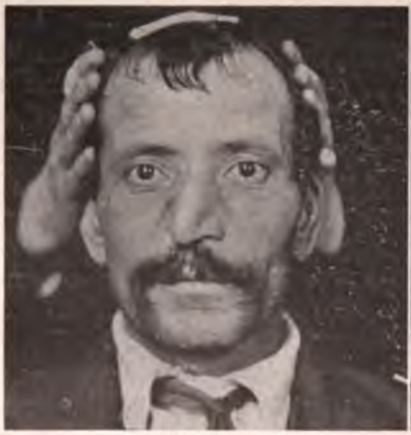

Fig. 460.

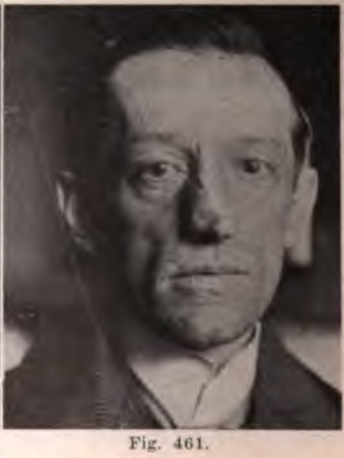

Fig. 461.

Fig. 460.—Separation and angular displacement of lateral and septal cartilages to patient's right.

Fig. 461.—Fracture of nasal bones with displacement to right. Partial separation of lateral and septal cartilages with displacement to left.

cutaneous cellular tissue. The nature of the late symptoms will vary according to the presence or absence of infection. The circulation is extremely free in this region, the vitality and resistance of the tissues great, and accordingly we find recovery more prompt and complete than might otherwise be expected. Necrotic bone is seldom seen, and infections, except when virulent, are short-lived. Suppuration, however, when once established, may persist for weeks if there are particles of necrotic bone present. The discharge will keep up until these pieces have been removed or thrown off.

Diagnosis.—Diagnosis of fracture of the nose is based upon the symptoms already enumerated; deformity, mobility and crepitus.

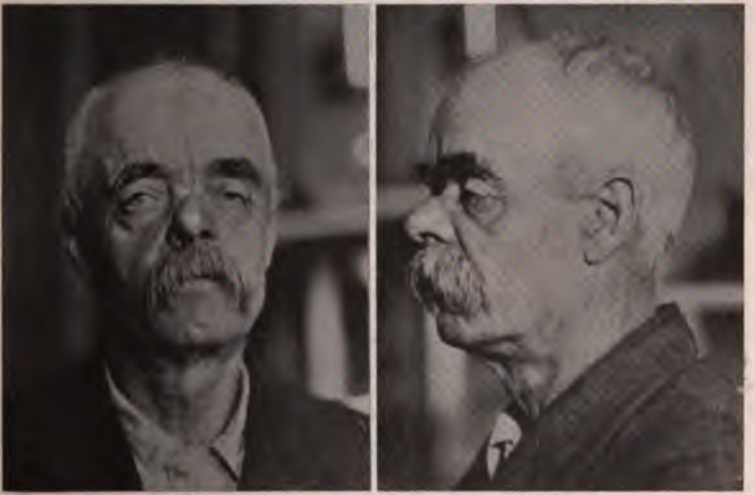

Fig. 462. Fig. 463.

Figs. 462 and 463.—Two views of a case of destruction of the nasal bridge due to syphilis. Deformity resembles deformity following severe fracture.

Deformity, as observed in these cases, is not as reliable from a diagnostic standpoint as it is in fractures of other regions. This fact is due to the variability of the normal nasal outline together with the frequent presence of old unreduced deformities following previous fractures.

If the bridge of the nose is gripped between the thumb and the index finger the stability of the bones may be ascertained and crepitus elicited. The question of mobility is rather variable. During examination it is not infrequently possible to displace the fragments from side to side with but slight effort; but on the other hand, we often see cases in which the bones have been forcibly displaced to one side and have apparently become wedged, requiring considerable force to return them to their normal relations. A long slender instrument similar to the divider, when properly passed upward behind the seat of fracture, will enable the surgeon to determine the internal contour of the nasal fragments. The diagnosis of fracture of the nose cannot be considered complete without ascertaining the condition of the osseous and cartilaginous nasal septum. This may be accomplished by direct inspection or by palpation with a probe.

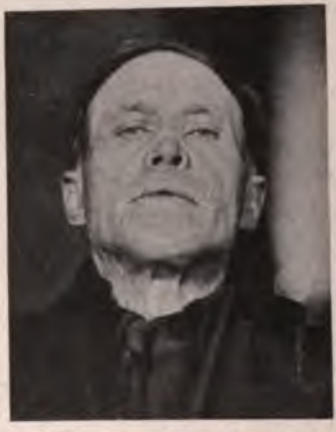

Fig. 464.—Falling in of cartilages in old case of syphilis.

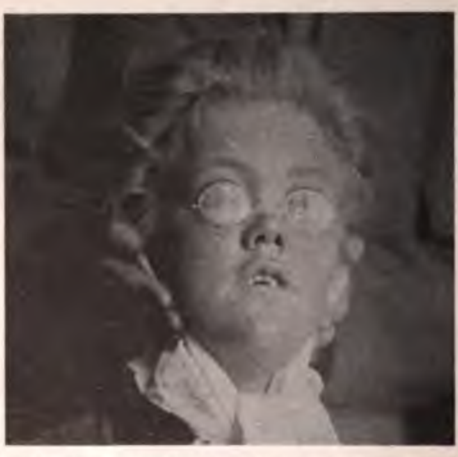

Fig. 465.—Case of saddle nose due to hereditary syphilis.

Treatment.—In dealing with fractures in this region the treatment must vary according to the severity of the injury. Severe compound comminuted fractures may, at times, become extremely difficult to manage. The indications must be considered in each and every individual case. Displacement, when present, must be corrected, and the fragments maintained in proper apposition. Reduction is usually best accomplished by combined external and internal manipulation. A small slender instrument which will approximately fit the posterior surface of the nasal bone is passed upward into the nose, the fragment raised and pushed back into position, with the assistance, externally, of the thumb and index of the opposite hand.

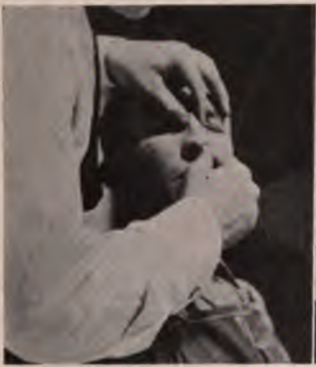
Fig. 466.

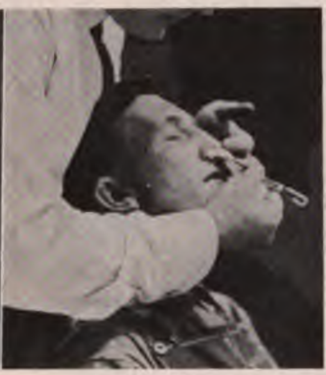
Fig. 467.

Fig. 466.—Raising the nasal bones by means of "divider" within the nasal cavity and moulding them into position with the thumb and index finger.

Fig. 467.—Packing nasal cavities with strips of gauze soaked in adrenalin to control hemorrhage and support bridge of nose.

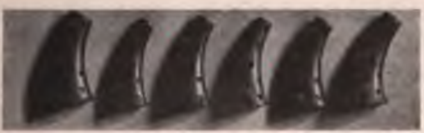
Fig. 468.—Asche nasal splints. (Different sizes.)

Both sides should be adjusted in this manner, and the contour of the nose carefully inspected and palpated to produce as symmetric a result as possible. At the same time we must be prepared to readjust the septum when it shows lateral displacement. The injuries seen in the septum are numerous, involving for the most part the quadrangular cartilage and the vertical plate of the ethmoid; the important point as far as treatment is concerned is the tendency toward displacement after the nasal bones have been replaced. Lateral bowing of the septum or overriding of the fragments should be reduced, and if there is tendency to recurrence of deformity some means of maintaining reduction must be employed. The tubular nasal splint will often accomplish all that is required but if some more secure method is needed pins may be introduced to hold the septum, as suggested by Roberts.[1]

Hemorrhage from the torn mucous membrane may be severe, but even when moderate at the time of examination there is no assurance that it will not be profuse a few hours later; it is therefore wise to pack the upper anterior portion of the nasal cavity at the first treatment. This will maintain the fragments in proper position and also serve as a pack to control hemorrhage from the lacerated portion of the mucous membrane. It is usually not necessary to pack the parts tightly enough to bulge the bridge of the nose; the strip of gauze however should be carried well up under the nasal bones before the packing is begun. If these strips of gauze are previously saturated with a 1 to 1,000 adrenalin chlorid solution we have an additional preventive against hemorrhage. When the case is first seen hemorrhage is, as a rule, the most important element to be dealt with, and for this reason it is best to employ the pack rather than the nasal splint, which

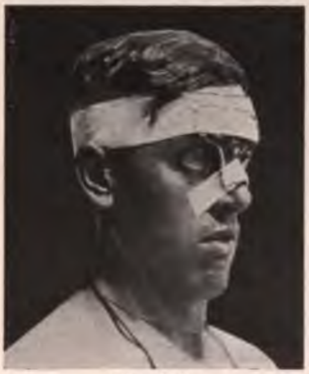

Fig. 469.

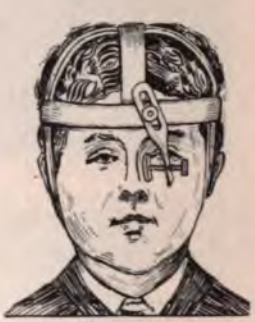

Fig. 470.

Fig. 469.—Author's moulded, dental composition, nasal splint.
Fig. 470.—The Cobb nasal splint.

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[1] "Surgery of Fractures and Dislocations of the Nose," in *Surg., Gynec. and Obstet.*, June, 1911. John B. Roberts, M.D.

finds a more appropriate place in the after-treatment of the case. We should attempt to reduce deformity immediately following injury, yet, if the hemorrhage is pronounced, it should be controlled even at the expense of perfect reduction. Later on when the danger of hemorrhage has passed, more accurate adjustment of the fragments may be made, and one of the various forms of nasal splint, commonly in use, employed. The same trauma which produces the fracture not infrequently lacerates the skin over the nose. When this is the case, we have the wound to treat as well as the fracture. Wounds when present should be thoroughly cleansed and the edges approximated. If the margins of the wound show much laceration the ragged edges should be trimmed away with a sharp scalpel before the sutures are placed. Either local or general anesthesia is advisable except in the most mild type of case. If the nose is gently packed for a few minutes with strips of gauze saturated in a four percent solution of cocaine, subsequent manipulations will be rendered almost free from pain and the surgeon's work is made much easier.

Operative Treatment.—There is little in the way of operative treatment in these cases aside from that already described. There are exceptional cases, however, in which it may be necessary to reconstruct the bridge of the nose or to correct old deflections of the septum or nasal bones which have resulted from old unreduced fractures. Pronounced depression may result either from the original trauma or from subsequent infection and sloughing. Syphilis is still another cause of falling of the bridge or cartilages and the resultant deformity should not be confused with the traumatic condition. Syphilitics often misrepresent their case and unless the surgeon recognizes the luetic nature of the condition, he may perform a plastic operation on the nose of an active syphilitic, while the specific processes are still destructive.

In correcting deflections and depressions of the bridge an attempt is made to bring the displaced portions of bone back into position after having refractured them as near as possible to the original seat of fracture. Much can be accomplished in the lower portion of the bone by incisions through the mucous membrane on the deep surface of the bones. When the deflection begins high up near the frontal refracture may be accomplished by a small subcutaneous incision and narrow chisel. After the displaced fragments have been refractured they are brought back into position and treated the same as a recent fracture. The septum requires attention and when deflected it may become necessary to do a submucous resection, as is done for deflections resulting from causes other than fracture. In some cases of saddle nose there is not sufficient bony tissue from which to reconstruct the bridge and the problem then becomes one not only of plastic surgery but also of bone transplantation. A bone transplant of appropriate size and shape is taken from the crest of the tibia, introduced within the tissues of the nose and the soft parts closed over it according to the plastic method best suited to the case in hand. When the bone transplant is used it should be shaped and placed to fit the needs of the particular case, and the denuded osseous material of the transplant should be brought firmly in contact with the denuded surface of the living bone, so that the reformative osteogenetic elements may find their way from the living bone into the transplant during the process of repair. The injection of paraffin to correct nasal depression has often been followed by satisfactory results, but on the whole cannot be recommended except in rare cases.

The most satisfactory suture, except where there is considerable tension of the parts, is horse-hair.

After Treatment. The gauze packs should not be allowed to remain in place more than forty-eight hours at the most and we should exercise the greatest gentleness in their removal in order that we may avoid the recurrence of hemorrhage. If the packs are allowed to remain longer they become foul, thus favoring infection and suppuration. We occasionally meet with cases in which both primary and secondary hemorrhage are difficult to control. If hemorrhage follows the removal of the packs, the inside of the nose is to be inspected to determine whether we have a general oozing or a hemorrhage from a single vessel. In cases where loss of blood from a single vessel is persistent it may become advisable to touch the bleeding end with a small electro-cautery. When the dangers of hemorrhage and infection are past the remaining desideratum consists in maintaining the fragments in position until union has taken place. In most cases the simple nasal splint (Asche splint) fitted into the upper nares will suffice. A slight degree of pressure may be maintained from the outside by strips of adhesive plaster applied across the bridge of the nose. Various types of complicated external nasal splints (such as the Cobb, Eisendrath, Neres, etc.) have been devised and used with success, but it is only in rare instances that they are of real service.

When external pressure is necessary to maintain the fragments in proper position we may employ the following method which is quite efficient and simple. A piece of dental composition, having been rendered pliable by immersing it in hot water, is applied to the nose and a mould of the parts taken with such pressure as may be necessary to maintain proper reduction. Cold water is then poured over the composition to harden it before removing it from the nose. The newly formed splint is then removed and trimmed as desired, after which it is replaced and secured by means of strips of adhesive plaster (see Fig. 469). If thought desirable, additional leverage may be obtained by extending the splint upward onto the forehead where it is again secured by transverse strips of adhesive. It is better not to employ any form of moulded splint until after the acute swelling has subsided, which will take from three to four days;—on the other hand, delay beyond the fifth or sixth day is not advisable since union in this region is often rapid. External pressure, however, is rarely needed if the essentials previously mentioned are properly followed out. Union should take place in the average adult in from ten days to two and a half weeks but it will be over a month and a half to two months before the parts should be subjected to any considerable pressure, and the patient should be cautioned in this regard. During the course of after-treatment the internal nasal splints should be removed at intervals of three to four days, and nasal douches employed daily to prevent the parts from becoming foul. Normal salt solution or one of the mild alkaline antiseptic washes will be found satisfactory as a douche. Subcutaneous emphysema, ecchymosis and swelling will, as a rule, subside during the first few days without the use of any special method for their relief.

Prognosis.—The prognosis is almost invariably good, yet we cannot guard too carefully against infection in this region. The deformity is almost always a matter subject to correction and aside from exceptional cases the ultimate cosmetic results should be good.

CHAPTER XXVI.

FRACTURES OF THE MALAR BONE AND ZYGOMATIC ARCH.

Surgical Anatomy.—Anatomically speaking the malar is a distinct bone, but from a surgical standpoint it becomes necessary to consider the various processes with which it articulates as a part of that bone, since fractures are rarely limited to the malar alone. The bone is roughly quadrilateral in shape, articulates with the frontal, great wing of the sphenoid, zygomatic process of the temporal and the malar process of the superior maxilla. It also forms part of the wall of the temporal and zygomatic fossæ and enters into the formation of the orbit. The bone is composed of heavy compact tissue, its strength being such that blows on the face usually result in impaction of its supports rather than fracture of the bone itself. The fact that the malar enters into the formation of the wall of the orbit and the zygomatic fossa, will lead to symptoms peculiar to these cavities when the bone is displaced. From a surgical standpoint the zygomatic arch is to be considered as a whole, and since the zygomatic process of the temporal and the malar both enter into its formation, these two structures are spoken of as one. The space beneath this arch is normally filled by the coronoid process of the inferior maxilla and the temporal muscle, and any inward displacement of the arch must encroach upon these structures and interfere with their function. Interference with the action of the lower jaw may sometimes result from the extravasation of blood or from swelling of the tissues beneath the arch, and we thus have a symptomatic simulation of bony depression. So-called fracture of the malar consists chiefly in impaction of the bone into the processes supporting it, especially that of the superior maxilla. The largest process supporting the bone is the malar process of the superior maxilla, and since the antrum of Highmore projects well up into this process (sometimes even penetrating into the malar) the fracture may open into the cavity of the antrum; when such is the case the manner in which air may be forced from the nasal cavity, through the antrum, into the conjunctiva, is evident. Thus the resulting subconjunctival emphysema, when present, indicates the condition of the underlying bone.

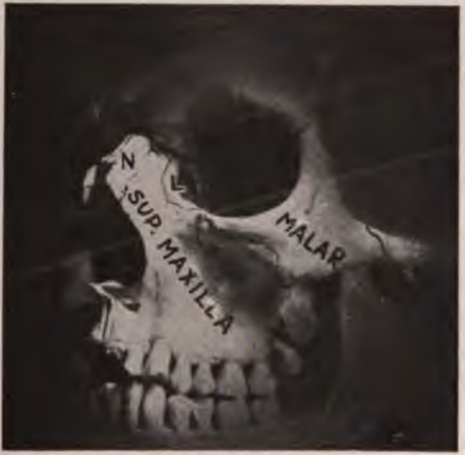

Fig. 471.—Relations of the nasal, lachrymal, superior maxilla and malar bones.

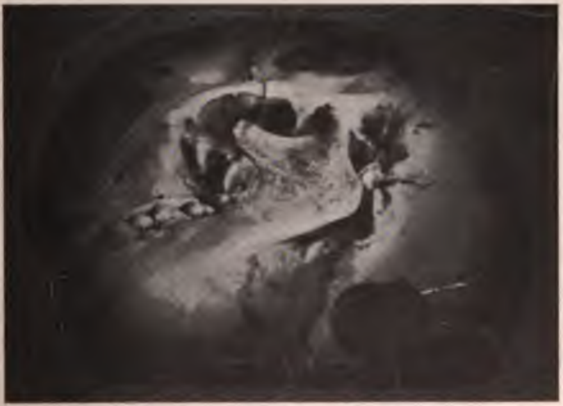

Fig. 472.—Zygomatic arch seen from below. Note the relations of the arch and the inferior maxilla.

In fracture of the malar the usual deformity consists in depression of the bone into the superior maxilla with a slight rotary displacement, so that the orbital border may be felt projecting into the orbit while the zygomatic process is displaced inward and downward (see Fig. 471). The malar is sometimes displaced directly backward so that the zygomatic surface encroaches on the space normally occupied by the temporal muscle and coronoid process. The condition is rare but when present may interfere with the function of the lower jaw.

The infraorbital canal runs close to the plane of suture between the superior maxilla and the malar, and when the latter is impacted into the former we may have injury to the nerves contained within the canal; namely the antero-superior dental, the middle superior dental, and the fibres which are later continued into the terminal branches. Accordingly, disturbances in sensation may occur in the upper teeth and gums as far back as the second bicuspid (inclusive) and in the terminal branches of the infraorbital on the face.

The subcutaneous tissue covering this region is loosely cellular and devoid of fascia, thus permitting of pronounced and rapid swelling which is so frequently a hindrance to diagnosis.

The muscles attached to this bone are three in number; two of them, the zygomaticus major and minor are muscles purely of expression, and hence disturbances in their function will be difficult to recognize; but the masseter, attached to the postero-inferior border, is a muscle of mastication, and disturbance in this function is readily detected.

The malar bone is sometimes normally divided into two parts by a horizontal suture, which anomaly should not be mistaken for fracture during operation or while exploring wounds.

The postero-superior border of the bone is continuous with the temporal crest of the frontal above, with the upper border of the zygoma below and has the heavy temporal fascia attached to it throughout its extent. The antero-superior border forms the lower and outer margin of the orbit and in this position is easily palpated, as is the postero-inferior border of the bone.

Etiology.—Fracture of the malar, like fracture of the nasal bones, is the result of direct violence, such as falls and blows on the face. It requires a much greater degree of violence, however, to fracture the malar than it does the nasal bones.

Symptoms.—Pain is a constant element, while mobility and crepitus are more often absent than present. Swelling is usually rapid and pronounced, and ecchymosis about the eye common. The patient will usually give a history of severe trauma and may present a number of variable symptoms according to degree and direction of the displacement. If the anterior and middle dental branches of the superior maxillary nerve have been injured there may be considerable pain, numbness and tingling of the gums and teeth of the affected side as far back as second bicuspid (inclusive). Fractures of the zygomatic arch or a backward displacement of the malar may be accompanied by disturbances in

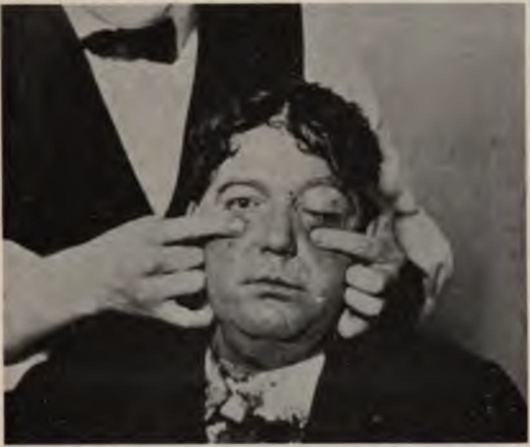

Fig. 473.—Fracture of the left malar bone a few minutes after injury. Note the swelling about the left eye and the way the examining finger sinks into the left side of the face. A number of air blebs were seen beneath the conjunctiva twenty-four hours later, the air having gained entrance to the tissues through the antrum.

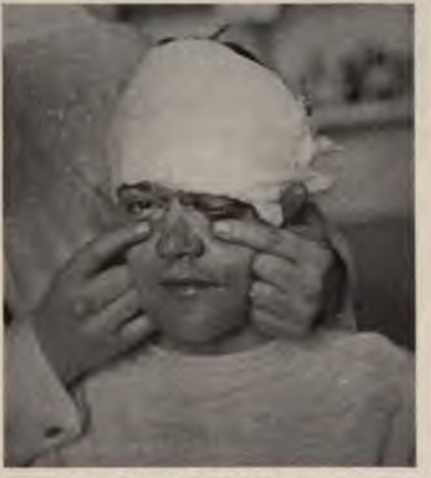

Fig. 474.—Fracture of left malar bone twenty-four hours after injury. Note how the finger sinks into the patient's face beneath the swollen, ecchymotic eye. A portion of the infraorbital ridge is depressed and may be palpated.

function of the mandible. There may be pain in the affected side on mastication; in severe cases the patient may be totally unable to move the jaw. The characteristic symptom will consist of a depression of the malar or zygomatic arch with a corresponding flattening of the cheek; this symptom however may be masked by swelling, within a few minutes of the injury, and unless a careful examination is made at the time, the true condition may be overlooked. Conjunctival ecchymosis is usually present and, in some cases, conjunctival emphysema.

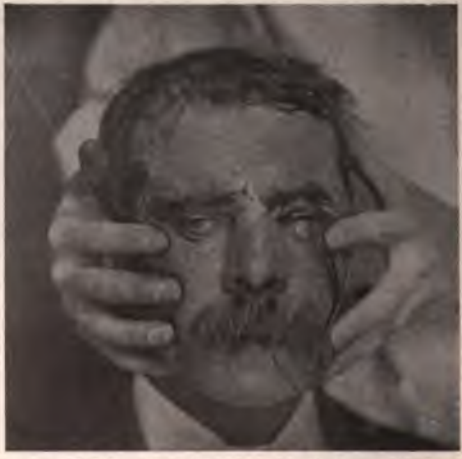

Fig. 475.—Fracture of the posterior portion of the malar and the anterior end of the zygoma on the left side of the face. Note how the examining finger sinks into the depression and compare it with the finger on the corresponding point on the uninjured side. Eye swollen shut and conjunctiva blood-shot. Photograph a few minutes following the injury.

Diagnosis.—If the swelling is not great the examination and diagnosis should be easy. The deformity which results from the depression of the malar or zygomatic arch is masked during the acute stage by the swelling, and unless a careful examination is made to determine the condition and position of the underlying bone we may learn subsequently to our chagrin what the real deformity is, after the swelling has subsided and union has taken place. Inspection alone, in these cases, is valueless since the visible symptoms are the same as seen in ordinary "black eye" (ecchymosis and swelling). We should therefore carefully palpate the parts to determine the position of the underlying bone. In most cases, continued pressure with the finger will displace the intracellular inflammatory fluids sufficiently to allow the surgeon to satisfactorily appreciate the conditions present, and to compare them with the facial contour of the uninjured side. The two sides can best be compared by standing behind the patient and palpating both bones simultaneously with the thumb and index finger of each hand (see Fig. 473). The presence of depression can be determined by placing the two index fingers over the prominent portion of the cheeks, and comparing the two sides; sufficient pressure on the injured side should be made to allow the finger to sink in, in order that we may eliminate the swelling which is otherwise misleading. The orbital, temporal and masseteric borders may be palpated and the position of the bone thus determined and compared. The conjunctiva should be examined for the purpose of detecting ecchymosis or emphysema; the former is by no means pathognomonic, but the latter is the result of air having passed from the nasal cavity into the conjunctiva, which is impossible if the bones of the face are intact.

Treatment.—The first indication in the treatment of these cases is to counteract the local effects of trauma and to relieve pain when severe. The inflammatory reaction can be maintained at the minimum by the use of the ice-bag for the first twelve to twenty-four hours. In most cases, an attempt to correct the deformity is purely for cosmetic reasons, and in considering this element we must take into consideration the surroundings of the case.

For example: deformity resulting from depression of the malar may be deemed an extremely important matter in the case of the young society woman, while, on the other hand, the average laborer would not consider for a moment the trouble, time and expense necessary for the correction of the disfiguration which in no way interferes with his earning capacity. When no attempt is made at correcting the displacement the case resolves itself firstly, into the control of local reaction; secondly, allowing nature to unite the impacted fragments; and thirdly, the treatment of accompanying wounds when present. If the fracture is compound as a result of direct violence the wound should be cleansed and the edges approximated according to general surgical principles as applied to the treatment of wounds and compound fractures. When complications exist, such as interference with the action of the jaw, or extreme and prolonged pain in the region of the superior dental nerves, operation is indicated.

Operative Treatment.—Operation may become necessary for cosmetic reasons or for the alleviation of complications such as the interference with the action of the jaw; the type of operation will depend to some extent on the reasons for which it is undertaken. When performed for cosmetic reasons only, open incision should be avoided, because of the resultant scar. In these cases, the bone may be approached from the mouth through an incision parallel with the alveolar process and opposite the malar process of the superior maxilla, the thick part of which may be felt opposite the first molar. This incision is carried up under the cheek until the malar is exposed, after which it is pried back into position and the incision closed. Another method is that of making a small incision through the skin, drilling a hole in the face of the malar and inserting a screw, by which means the bone may be raised and replaced. Any modification of an intraoral operation should be conducted with due consideration for asepsis and followed by frequent douchings. Deformity has been successfully corrected by the subcutaneous injection of paraffin, though the method is somewhat questionable. The difficulty with operative treatment is not so much a question of replacing the bone as it is of maintaining it in its original position, and the reason for this difficulty is explained by the loss of bony tissue which takes place in impaction. In other words it is not difficult to reduce the deformity, but we do not have the supporting process intact to maintain reduction after the impaction has been broken up. In Lothrop's operation the bone is approached through the mouth as previously described, the depression corrected and the antrum packed with gauze to maintain the malar in its elevated position. The gauze is left in place for four or five days. The cavity is packed a second time—if there is tendency toward a recurrence of the deformity—and left for a second period of four or five days. The danger in this operation consists of infection, which is favored by allowing the packs to remain during the period indicated. Some of the more recent work done with bone transplants would suggest the use of bone wedges taken from the tibia to support the malar in its raised position, the wound being closed without drainage. Fracture and depression of the zygomatic arch call for reposition of the fragments; this is most satisfactorily accomplished by means of a direct incision exposing the bone. If the incision is made parallel to, and a short distance above the

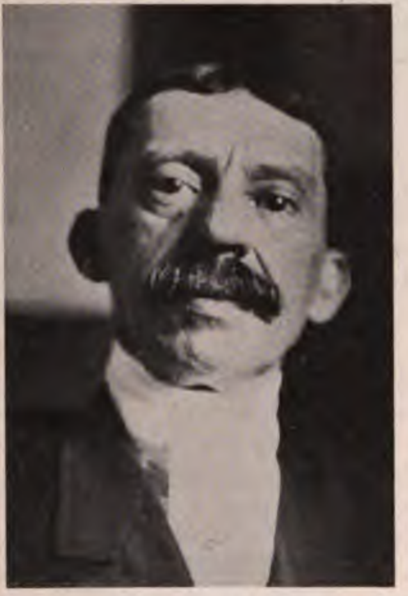

Fig. 476.—Depressed fracture of right malar of two years' standing. Note hollow under patient's right eye. Deformity moderate. Compare this deformity with that seen in case shown in Figs. 477 and 478.

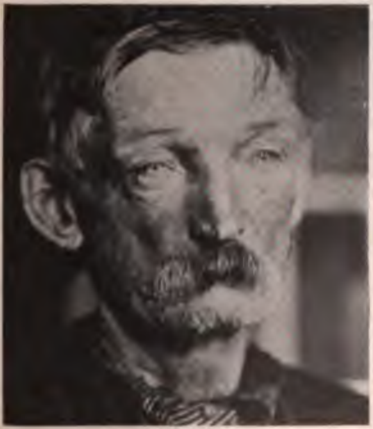

Fig. 477.

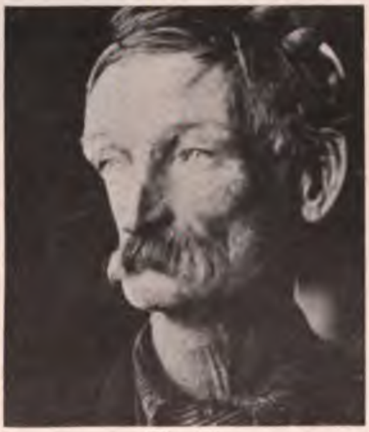

Fig. 478.

Figs. 477 and 478.—Old depressed fracture of the right malar with pronounced deformity. Note the flattened cheek which is best appreciated in profile. Patient gives history of severe direct violence with practically no treatment following same.

arch we can frequently replace the bone and still have the resultant scar in a position which will be covered by the hair after recovery is complete. Care should be taken to accurately approximate the temporal fascia before closing the wound. Sensory disturbances in the course of the dental nerves will usually clear up, but when severe may call for operative intervention to relieve the pressure. Pain in the terminal branches of the infraorbital nerve can sometimes be controlled by a hypodermatic injection of alcohol into the nerve as it emerges from the infraorbital foramen.

After-Treatment.—The after-treatment in the ordinary case consists of the avoidance of additional trauma, and allowing Nature to unite the fragments. No retentive apparatus is necessary and dressings are not called for except in compound cases. The mouth and nose should be kept clean by the use of antiseptic douches to avoid the possibility of infection by way of the antrum.

Prognosis.—Deformity is a common result of fracture of the malar, and even though operative intervention may reduce the displacement it is rarely possible to return the fragments perfectly to their original positions. Neuralgias may follow the condition, but usually subside within a few months even if allowed to go untreated. Interference with the action of the lower jaw following depression of the arch is a condition which has been followed by recovery of function even in cases where no treatment has been employed.

CHAPTER XXVII.

FRACTURES OF THE SUPERIOR MAXILLA.

Surgical Anatomy.—The superior maxilla may be considered the shell which forms the wall of the antrum of Highmore, and from this shell we have projecting in various directions, processes of bone which articulate with the adjoining bones of the face and cranium. The different regions into which these processes project and their several functions render the subject of fracture of this bone diverse.

The *nasal process* extending upward, inward and backward, articulates with the nasal, lachrymal, frontal and ethmoid bones, and enters into the formation of the nasal cavity, the orbit, the anterior ethmoidal cells and the lachrymal canal. Fracture of this process is associated with fracture of the nasal bones and for surgical purposes is to be considered under fractures of the nose.

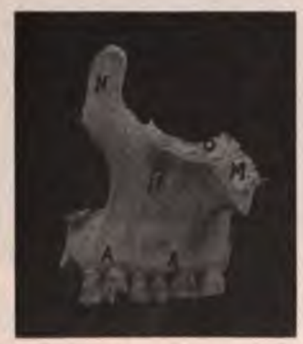

Fig. 479.—Superior maxilla. *N.*, nasal process; *M.*, malar process; *O.*, orbital process; *I.F.*, infraorbital foramen; *A.A.*, alveolar process. (See Fig. 471.)

The *alveolar process* is thick and arched and is hollowed out into sockets corresponding in number, depth and width to the sixteen upper teeth. A portion of the alveolar arch is not uncommonly fractured in the extraction of teeth, but the injury is not, as a rule, of serious import provided the line of fracture is confined to this process.

The *malar process* is thick, composed of a heavy tissue, supports the malar bone and sustains most of the impaction when the malar is driven into the face. It is therefore best considered with fractures of the malar.

The *palatal process* forms the greater part of the roof of the mouth and in this position is rarely subject to injury. It is sometimes, however, fractured by falls on objects held in the mouth, and is not infrequently the site of suicidal gunshot injury.

Fracture of the *body of the bone* may occur from blows on the face especially in instances in which the malar is impacted into its substance. Fractures of the body involve the antrum of Highmore and are therefore compound connecting with the outer air through the nasal cavity. In comminuted fractures, especially gunshot injuries, the fragments may be driven into any adjoining cavity (orbit, nasal cavity, zygomatic fossa, temporal fossa, mouth) or they may be displaced into the antrum itself. We may have a vertical line of fracture separating the bones of the two sides, or a horizontal fracture disarticulating the maxilla from the frontal. Another form of horizontal fracture situated at a lower level, separates the alveolar and palatal processes from the rest of the bone. Such fractures are necessarily the result of severe direct violence, such as a fall from a height or a kick from a horse. The relation of the antral cavity to the surface of the bone, and the manner in which the palate, inferior turbinate, and ethmoid close in the opening between the antrum and the nose are of surgical importance as regard drainage in cases of infection. The antrum may be entered by way of the nose, through the canine fossa, or by extraction of the first or second molars. The circulation in the region of the face is extremely free, accounting for the rarity with which necrosis occurs in the fragments and the manner in which loosened teeth regain their solidity. A considerable portion of the superior maxilla is covered with mucous membrane, which is usually torn if the fracture involves this region; we should therefore examine the nasal and oral cavities in making a diagnosis.

Symptoms.—Deformity is very variable and may be entirely masked by the swelling which is likely to be pronounced and follows the injury rapidly. The most common displacement consists in depression of the fragments, the face being "driven in" to a greater or less extent, in the region of the injury. Hemorrhage from the nose or mouth is prone to occur, and emphysema is sometimes seen as a result of air having been forced into the tissues from either the oral or nasal cavities. Depression in the region of the antrum is most common. Mobility and crepitus are variable and their absence should not lead us to exclude fracture. Loss of alignment in the teeth and mobility of a section of the alveolar arch are usually present when the fracture involves this process. The symptoms in general will vary greatly according to the region of the bone involved and the associated injury of the soft part. We sometimes see cases in which the face is so severely crushed that it is no longer a question of which of the facial bones is fractured but,—have any escaped?

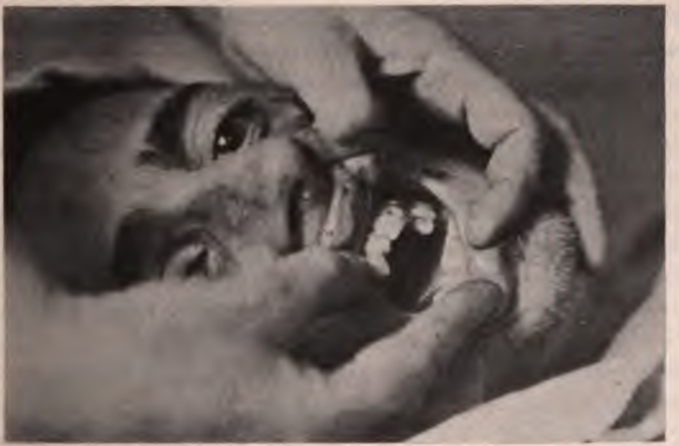

Fig. 480.—Fracture of superior maxilla. Patient injured in automobile wreck. Fracture extends through alveolar process, body of bone and through the orbital process. Posterior fragment displaced downward as may be seen by the disturbed dental alignment.

Diagnosis.—The upper jaw is examined in a manner similar to the malar. The outline of the upper portion may be palpated through the face and its two sides compared. The lower portion of the bone and the teeth may be examined through the mouth, and the lateral wall of the nasal cavity inspected through the nostril. Mobility may rarely be elicited by making pressure on the face in various direction. Crepitus is likewise an uncommon symptom.

Treatment.—The treatment of fracture of the superior maxilla, like the symptoms, varies according to the region of the fracture. Fracture of the nasal process is treated similarly to fracture of the nasal bone, and is included under that heading. Fracture of the malar process is a condition very similar to so-called fracture of the malar, and is treated in a like manner. Fracture of the body of the bone frequently calls for some method of elevating the depressed fragment, and this may often be accomplished through the mouth, thus avoiding a scar of the face. Fracture of the superior maxilla is very commonly associated with severe lacerated wounds of the face, and when such is the case we have the wound to deal with in addition to the fracture itself. The vitality of the tissues is high on account of the free circulation, and accordingly it will seldom be necessary to remove fragments of bone or to trim away torn tissue unless manifestly devitalized. Lacerated wounds of the face should be freely washed with normal salt solution in order to remove infectious material which has been driven into the tissues, and wounds of the mucous membrane communicating with the fracture through the mouth should be frequently and freely irrigated in order to avoid subsequent infection. Fracture of the alveolar arch is to be treated according to the requirements of each individual case. When there is no tendency toward displacement of the fragments the chief indication is that of cleansing with a mild alkaline solution. If there is displacement of teeth and disturbed occlusion through loss of alignment it may become necessary to hold the fragments in position by wiring the teeth or by means of an aluminum dental splint as described in the treatment of "Fracture of the Lower Jaw" (page 357). Separation of the two superior maxillæ may also be immobilized in the same manner. Openings through the palatal process should, except in cases of simple fissure, be protected from the mouth during the process of healing by a hard rubber plate. In gunshot injuries, the area of fracture may be protected from contamination by food, and the nasal and oral cavities separated in this manner.

Operative Treatment.—Operative treatment is indicated in severe compound cases. It will be impossible, however, to lay down any hard and fast lines of procedure, since the needs of each and every individual case will vary, and the surgeon will find it necessary to meet the demands of the case in hand.

After-Treatment.—The chief indication of after-treatment will be to keep the parts clean, prevent infection and allow nature to unite the fragments. In the presence of infection we should see to it that the antrum is freely drained; this may be accomplished by the extraction of the first or second molar or by perforating the anterior wall of the antrum above the roots of these teeth. The antrum may also be entered and drained through the inferior or middle meatus; when the opening is made through the inferior meatus it may be necessary to previously remove the inferior turbinate. During the early part of the after-treatment the nose should be irrigated three to four times daily and the oral cavity should receive equally careful attention.

Prognosis.—Union usually takes place in from six weeks to two months. Prognosis as to life is good except in severe crushing injuries of the face in which shock is great, and associated injuries of the skull and brain probable. The prognosis as to deformity is frequently not good in fracture of the body of the bone. Fracture of the nasal process can usually be treated without subsequent deformity. Fracture of the malar process is not so favorable in this respect.

The presence of infection renders the prognosis worse but if proper treatment be established without delay and efficient drainage and lavage maintained the outcome should in most cases be good. In fracture of the alveolar process small sloughs of bone may require removal but this does not signify that the ultimate outcome will not be good.

CHAPTER XXVIII.

FRACTURES OF THE LOWER JAW.

Fracture of the lower jaw is a common injury, constituting nearly four percent of all fractures, and, since the bad results so often seen are due to mechanical and anatomical causes, it is evident that an intimate understanding of the anatomy of the parts is essential to the successful treatment of this fracture.

Surgical Anatomy.—The inferior maxilla or mandible is the largest and strongest bone of the face and, with the exception of the nasal bones, is most frequently fractured. It is composed of the body, ramus, and two processes; the coronoid and condylar.

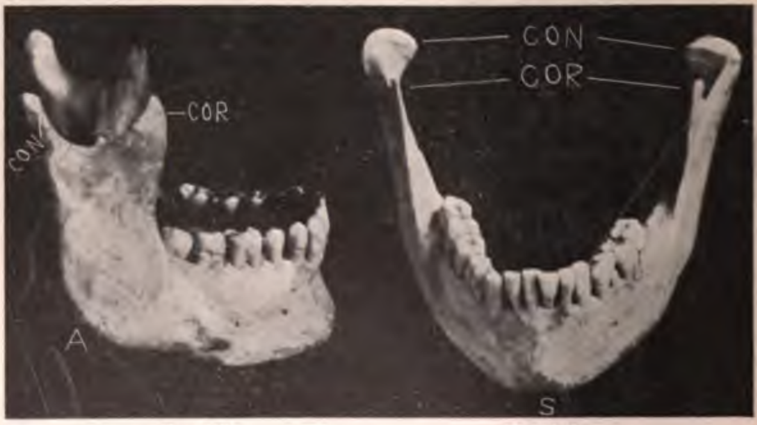

Fig. 481. Fig. 482.

Figs. 481 and 482.—Two views of the mandible. *Con.*, Condyloid process; *Cor.*, Coronoid process; *A.*, Angle of jaw; *S.*, Symphysis.

Its position is very much exposed to violence, but, on the other hand, there are numerous elements which render the bone capable of withstanding considerable trauma without fracture. Its weight is considerable and the structure heavy, its mobility great, and the buffer-like action of the interarticular fibro-cartilage of the temporo-maxillary articulation serves to maintain the integrity of the bone in the presence of a blow. In addition the horseshoe shape of the body imparts a certain spring to the bone which is protective. The manner in which the fragments of the body are displaced will depend on the muscles attached to the bone. To the external surface in the region of the chin, we have the levator menti, while along the external oblique line are seen the attachments of the depressor labii inferioris, depressor anguli oris and platysma myoides. These muscles with the exception of the last named extend upward toward the chin, are small, and of minor importance in displacements. The buccinator is attached to the alveolar margin opposite the three molars. The masseter, a powerful muscle, occupies the external surface of the ramus, and pulls in an upward direction. The coronoid process is taken up by the insertion of the temporal muscle, which has a displacing action similar to that of the masseter. The internal surface of the body has the mylo-hyoideus arising from the mylo-hyoid ridge, and the genial tubercles have attached to them the genio-hyoglossus and the genio-hyoideus. One of these muscles enters directly into the formation of the tongue, while the remaining two are attached to the hyoid bone and when their anterior bony attachments are displaced backward, as is sometimes the case in bilateral fractures, we have backward falling of the tongue. This condition, especially during unconsciousness, may cause asphyxia if the tongue is not pulled away from the epiglottis by direct forward traction on the tongue itself, or by drawing the displaced fragment forward. To the posterior surface of the symphysis below the genial tubercles we have the diagastric muscles attached on either side. The pull of this pair of muscles is downward, backward and slightly outward. The superior constrictor of the pharynx has an attachment internal to and behind the last molar. The internal pterygoid is attached to the deep surface of the ramus in the region of the angle, while the external pterygoid is attached to the internal surface of the condylar process. These muscles have a lateral displacing action in fractures of the lower jaw; the common inward displacement of the posterior fragment is largely due to the unopposed action of the internal pterygoid. The temporal and masseter produce the usual upward displacement of the posterior fragment. As a result, therefore, of the combined action of these muscles the posterior fragment, in fractures of the body, will usually be displaced upward and inward (see Figs. 485 to

489). Accordingly in the correction of the deformity and during the subsequent immobilization of the fragments it is the displacing action of these muscles with which we have to contend.

In fracture of the body of the bone wide displacement of the fragments is usually prevented by the line of fracture passing through the attachment of some of the muscles, especially the mylohyoideus which is, as a rule, attached to both sides of the line of fracture. The masseter and internal pterygoid tend in like manner to limit the separation of fragments when the ramus is fractured.

On the internal surface of the ramus we have the inferior dental foramen for the passage of the inferior dental nerves and vessels which pass through the substance of the bone supplying the teeth of the lower jaw. Injuries to these structures sometimes occur, though not as commonly as might be inferred. The long root of the canine and the mental foramen are both considered elements of weakness in the structure of the inferior maxilla; it is in this region that fracture most frequently occurs. The mucous membrane is torn in most cases of fracture of the body and accordingly the break is usually compound.

It should be remembered that the facial artery passes onto the external surface of the body of the bone just anterior to the antero-inferior angle of the masseter muscle. From a point behind the posterior border of the ramus of the jaw we have the beginning of the pes anserinis, comprising the motor fibres running to the various muscles of the face. Stenson's duct runs directly forward from the parotid gland and empties opposite the second upper molar. The positions of the artery, nerve and duct are of importance when the fracture is accompanied by wounds of the face. In fractures of the condylar process the upper fragment may be displaced forward and inward by the action of the external pterygoid pulling in the direction of the external pterygoid fossa. Fracture of the coronoid is extremely rare, occurring only in conjunction with fracture of other bones in this region, such as the zygomatic arch. It is said however to have been broken as a result of muscular action.

Etiology.—Direct violence is responsible for most fractures of the inferior maxilla. Fractures due to indirect violence are seen in instances in which the symphysis has been fractured by lateral compression, the condyle broken off by a blow on the chin and in avulsion of the coronoid tubercle, as a result of muscular action.

Symptoms.—The symptoms of fracture of the inferior maxilla will depend upon the following conditions: the region of the break,

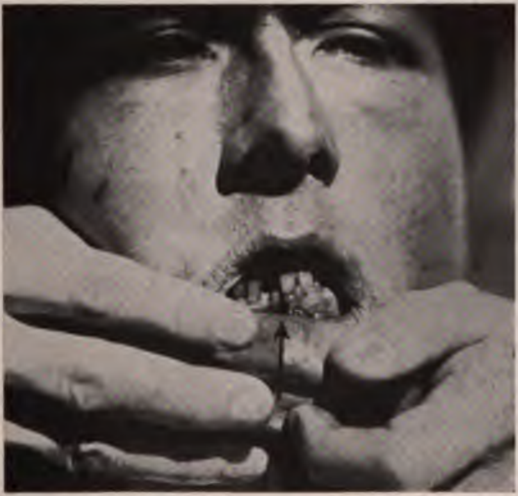

Fig. 483.—Fracture of mandible at symphysis. Mobility apparent on palpation or when patient attempts to speak. Arrow indicates line of fracture. Right central incisor loose.

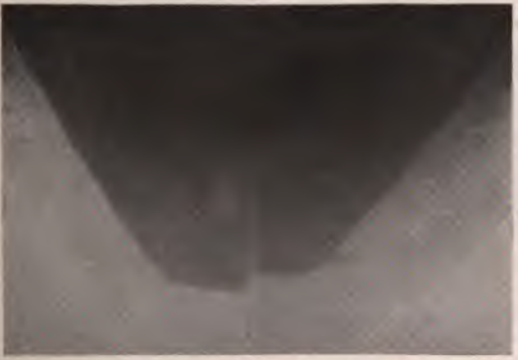

Fig. 484.—X-ray plate of same case showing line of fracture.

the degree of the causative trauma, and the displacing action of the muscles attached to the fragments. There will be swelling, tenderness, pain, deformity, abnormal mobility, loss of function and crepitus. Swelling is usually pronounced and follows the injury rapidly. Tenderness and pain are present in the region of

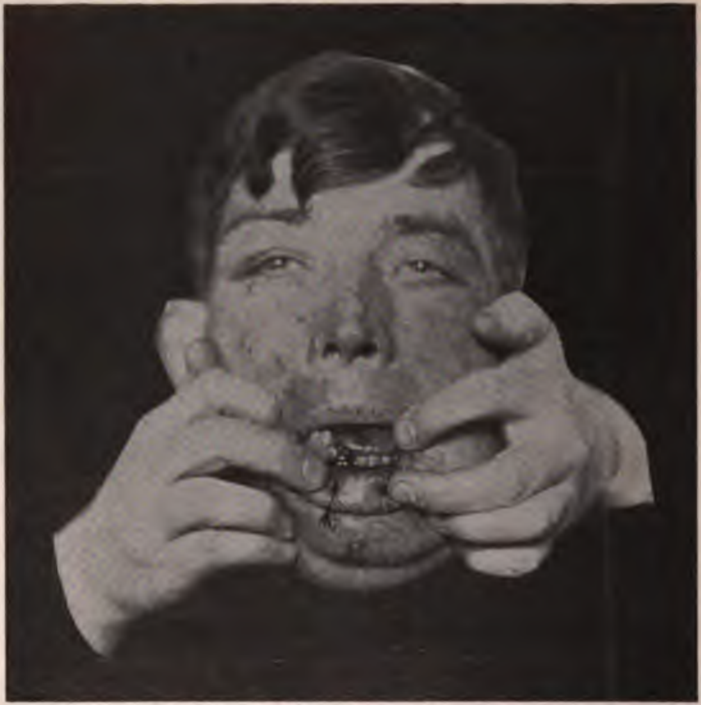

Fig. 485.—Fracture of the lower jaw just anterior to the right canine. Note the upward displacement of the posterior fragment. The dark shadow between the lower teeth and lip is blood which is coming from the fractured surfaces and torn mucous membranes. Photograph taken shortly following accident. Arrow indicates line of fracture.

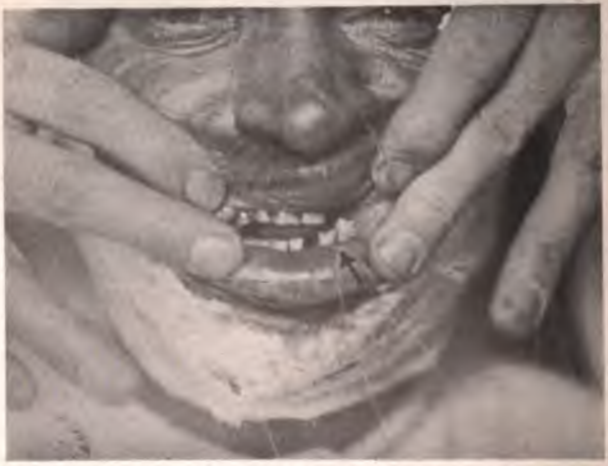

Fig. 486.—Fracture of lower jaw at the point indicated by the arrow. Note loss of alignment of the lower teeth.

the break, and are increased by any attempt at using the jaw. The deformity accompanying the usual fracture in the neighborhood of the canine is characteristic: the posterior fragment is displaced upward and inward, and loss of alignment in the teeth (except in edentulous cases) is apparent upon examination. Fracture behind the last molar, in the ramus or in the condyle is rarely seen, but when it does occur the deformity is less easily detected.

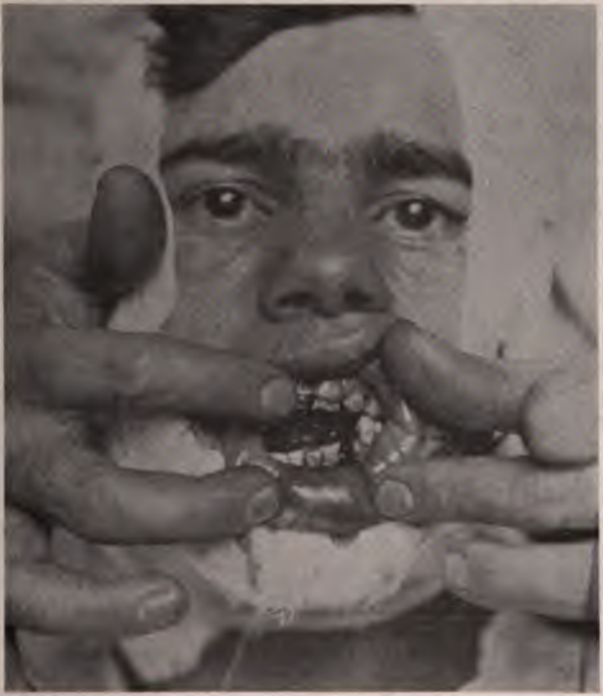

Fig. 487.—Fracture of the lower jaw about twenty-four hours following injury. Line of fracture passes between the lateral incisor and canine on the left side. Note how the posterior fragment is raised. In this instance the fracture is a little oblique so that the fractured surfaces have engaged in such a manner that the posterior fragment is prevented from the usual inward displacement.

The anterior border of the ramus, however, may be palpated from within the mouth with little difficulty even in cases where swelling of the face is pronounced enough to prevent opening the mouth. In such cases the finger is passed between the cheek and the teeth, and carried back far enough to determine the outline of the anterior margin of the ramus. In addition to direct palpation we may detect abnormal mobility by placing the fingers of one hand on the ramus of the jaw externally, while the opposite hand moves the chin. Fracture in the region of the symphysis is readily detected by inspection and palpation. The functions of mastication and articulation are interfered with from the first and on account of the subsequent inflammatory reaction become progressively more pronounced in the earlier stages of the condition. Crepitus can, in most cases, be elicited, but is usually not necessary in diagnosticating the condition. We should only attempt to produce crepitus after other means of ascertaining the presence of fracture have failed; the less the fragments are manipulated the better it is for the patient. The usual case presents a characteristic picture: the patient suffering considerable local pain presents himself for treatment because of severe injury sustained in the region of the jaw, one side of the face shows swelling, and may or may not be accompanied by a wound. The lips and teeth are slightly separated, the

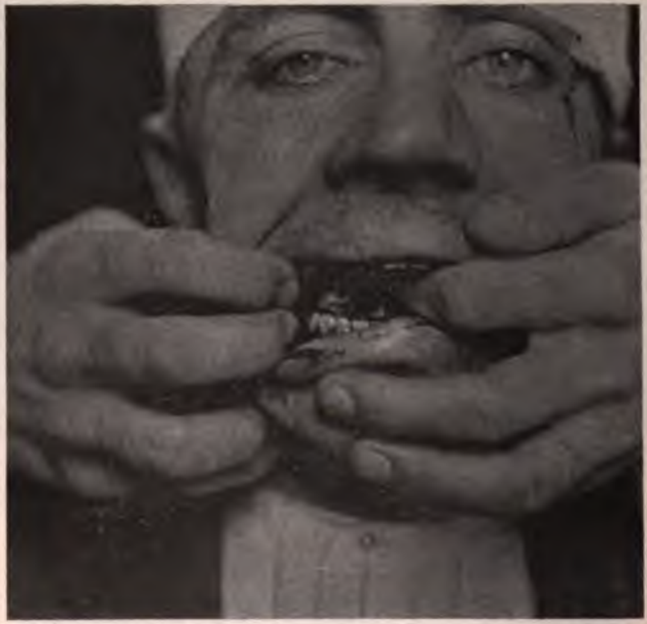

Fig. 488.—Fracture of lower jaw immediately following injury. Line of fracture passes between the second bicuspid and the first molar on the right side. Note how the posterior fragment is displaced inward and remains raised when the mouth is opened as a result of the unopposed actions of the right temporal and masseter muscles. This is the usual deformity and should be particularly guarded against in the treatment. If the deformity is allowed to go uncorrected there will result faulty dental alignment, malocclusion and the chin will be displaced toward the injured side. The further back the line of fracture the greater the leverage of the displacing muscles.

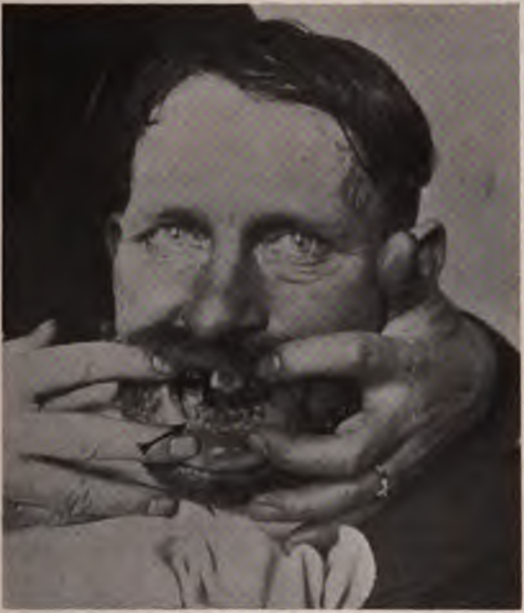

Fig. 489.—Fracture of the right side of mandible about six weeks after injury and after union had taken place. First seen by author at this time. In this case the inward displacement of the posterior fragment caused by the internal pterygoid muscle has been allowed to go uncorrected and malocclusion and displacement of the chin toward the injured side has resulted. The displacement of the chin is best appreciated when the jaws are closed.

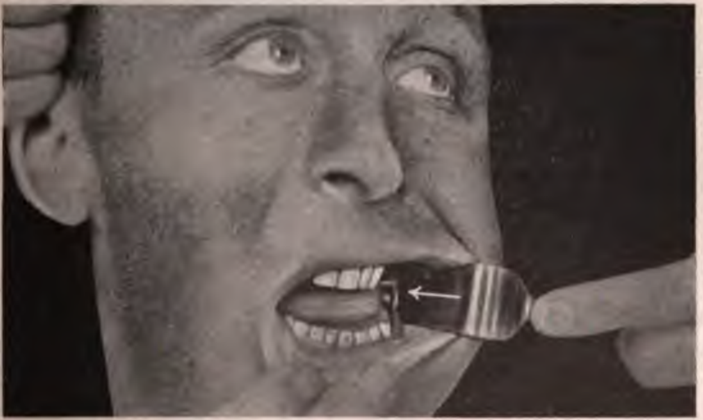

Fig. 490.—Fracture of the mandible behind the last molar on the left side. Posterior fragment displaced upward so that the fractured surface may be seen. Photograph retouched. Anterior surface of raised posterior fragment outlined to direct attention to its position. Reduction accomplished through incision at the angle of the jaw and wiring of the fragments. Case seen with Dr. H. R. McGraw.

patient is unable to talk with any degree of distinctness, saliva drools from the mouth, and on inspecting the teeth we find the characteristic upward and inward displacement of the posterior fragment with loss of dental alignment. Manipulation of the parts increases the suffering. If the case has been allowed to go untreated for a few days we have added to the above symptoms those of putrefactive changes within the oral cavity; there is a foul, characteristically offensive odor, and pus may be mingled with the saliva.

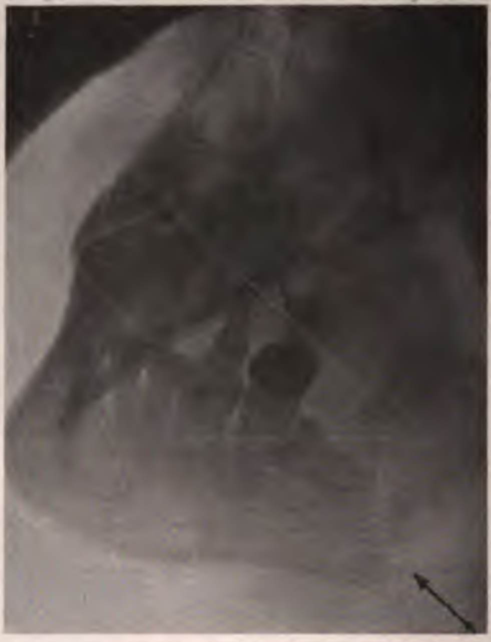

Fig. 491.—Röntgenogram of case similar to the one shown in Fig. 490. Note the loosened and displaced last molar.

Diagnosis.—The presence of fracture can almost always be determined by palpation and inspection. The diagnosis is based on the presence of the symptoms just enumerated. The condition is usually so easy to recognize that it is common for the patient to make the diagnosis before he is seen by the surgeon. Fracture of a portion of the alveolar arch accompanying the extraction of teeth sometimes goes unrecognized. Probing the socket will usually determine the condition if fragments are present. Fracture of the ramus or condyle in some cases calls for the use of the X-ray, to clear up the diagnosis.

Treatment.—Fracture of the inferior maxilla is a condition which has been treated from time immemorial with poor or indifferent success; it is, however, only within recent years that more accurate and satisfactory results have been attained, due to the introduction of improved methods, such as the intraoral splint in its various modifications, wiring the jaws together, and direct operative procedures. Reduction of the displacement is usually easy but the difficulty arises when we come to immobilizing the fragments. The different methods employed all attempt the attainment of two ends: firstly, the reduction and permanent correction of the deformity, and secondly, the prevention of infection. The various principles followed and appliances devised to accomplish these results are too numerous to mention; we will consider under the following headings only those which have been found most satisfactory.

1. Simple binding of the lower jaw against the upper by means of the fourtailed bandage.
2. Some form of interdental splint and the fourtailed bandage. (Gunning.)
3. Dental splint with arms attached for counter-pressure beneath the jaw. (Kingsley, Ackland, Matas.)
4. Dental splint cemented to the teeth. (Heath.)
5. Wiring the lower to the upper teeth. Oliver's method, Simple wiring, Angle bands with wire.
6. Securing the fragments by means of wiring the teeth of the lower jaw.
   Wiring of teeth adjacent to fracture. Hammond's wire splint, Angle bands with connecting bar.
7. Operative treatment. Direct wiring or plating of the fragments. Bone transplantation.

All of these methods have their points of advantage and their drawbacks, but from among them we are enabled to select the one best suited to the case in hand.

1. *Simple binding of the lower jaw to the upper* is the oldest method known and in the presence of modern facilities is only mentioned to be condemned. As an emergency method, however, it has its uses and will tend to keep the fragments at rest and more

or less opposed until some more accurate means can be employed. Its disadvantage consists in its persistent tendency to loosen, which may, to some extent, be corrected by strips of adhesive plaster placed over the cloth after the bandage has been applied. The dressing may be tightened in this manner as often as it becomes loose during the after-treatment. A fourtailed bandage may be made entirely of adhesive as follows: a three-inch strip of adhesive long enough to encircle the head (from the chin to the lambda) one and one-half times, is split on either end leaving a solid piece of about two inches in the middle. This middle piece is applied to the chin, the head having been previously covered by a layer of gauze. The two lower tails are carried upward and slightly backward, and attached to the gauze with sufficient traction to secure the lower jaw against the upper. The upper pair of tails is then carried backward to meet and overlap in the occipital region. (Figs. 492 and 493.) After this has been done the superfluous gauze is trimmed away and we have a dressing much more secure than the ordinary fourtailed bandage. During the after-treatment the dressing may be tightened by additional strips of adhesive without disturbing the parts. In securing the lower jaw to the upper in this manner, extreme care must be taken to keep the mouth clean during the after-treatment. The approximation of the lower teeth to the upper insures perfect occlusion, but the employment of external pressure alone is too insecure to

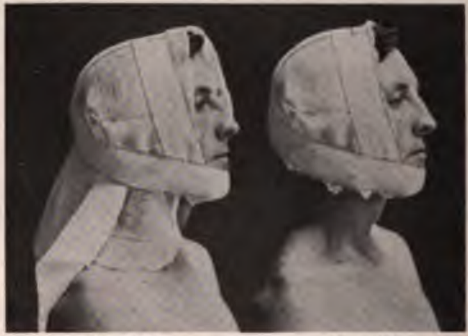

Fig. 492. Fig. 493.

Fig. 492.—Four-tailed bandage made with adhesive plaster. Head has been covered with gauze to prevent adhesive coming in contact with hair.

Fig. 493.—Same with superfluous gauze cut away. Dressing completed. More convenient and neat than either the ordinary four-tailed bandage or the plaster bandage.

be relied upon and must be accompanied by some additional method of internal fixation.

2. *Interdental splint with fourtailed bandage.*

Various materials have been used for interdental splints but none have been found as serviceable and satisfactory as vulcanized rubber. The production of the hard rubber interdental splint (Gunning) requires a certain amount of laboratory technique, familiar, as a rule, only to the dentist; when such services can be obtained by the surgeon the treatment is rendered much easier. In making a vulcanite interdental splint it is necessary first to take impressions of the upper and lower dental arcades. These impressions may be taken in wax, dental composition, or plaster. After the impressions have been taken a counter-impression of each is made with plaster of Paris. These counter-impressions of the upper and lower teeth are next properly trimmed and mounted respectively on the upper and lower arms of a dental articulator. Then by means of a fine saw the lower cast is cut in the region of the fracture, and the portions of the cast representing the fragments are brought back into alignment. The reduction is next tested by closing the articulator, thus bringing the lower teeth against

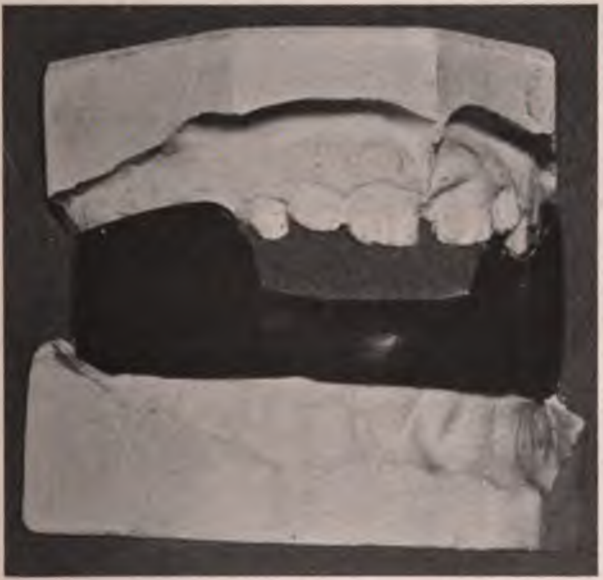

Fig. 494.—Interdental splint of vulcanite with opening for feeding of liquids.

the upper. Further corrections must be made when necessary for the production of perfect occlusion. When proper occlusion with the upper teeth is produced we have the exact position which should be occupied by the fragments of the mandible. The sawed portions of the lower cast are then fixed with plaster in the corrected position, after which the articulator is opened until the casts are in the same relative positions which the upper and lower jaws should occupy during the after-treatment. The interval between the upper and lower dentures is then filled in with beeswax and worked out in detail of the size and proportion desired for the interdental splint. Openings in the splint for the admission of food must be provided for. The two casts together with the intervening wax are next removed, being cut in such a manner that only that portion of each cast representing the teeth and gums is included. The two cut-down casts with intervening wax form are then placed in a vulcanizing flask (their relations being undisturbed), and plaster poured into the flask until it rises half way up the wax form. This is allowed to set and dry after which the surface is shellacked and covered with powdered soapstone. The second half of the mould is then made by pouring in plaster which is allowed to set; then the two moulds are separated and the wax melted out with hot water. When the wax is removed we have a cavity in each mould which when taken together correspond to the built-up wax form which was made on the articulator. These cavities are then packed with dental rubber, the moulds put together again and placed in a vulcanizing flask, the process now being the same as that employed in making the ordinary dental plate. When vulcanization is complete the splint is removed for finishing and polishing, after which it is ready for use. This form of splint is particularly useful when other methods would be unsatisfactory because of partial or complete loss of teeth. When the patient wears a complete set of false teeth these may, by proper alteration, be used as a splint during the after-treatment of the fracture, or a splint may be made by impression from that portion of the plate coming in contact with the gums. Wedges of dental composition or gutta-percha may be used between the teeth as splints. They are much more easily applied but are not as satisfactory as the vulcanite splint, and do not allow the drinking of hot liquids while in use.

3. *Dental splint with arms for counter-pressure beneath the chin.*

—The chief representatives under this heading are the appliances devised by Kingsley, Ackland and Matas.

Kingsley's appliance is a moulded splint conforming with the irregularities of the inferior dental arcade and holds the fragments in reduction by means of counter-pressure beneath the chin. Two lateral arms are secured to the splint which emerge through the mouth and afford attachment laterally for bandages passing under the jaw. The body of the splint may be made of various

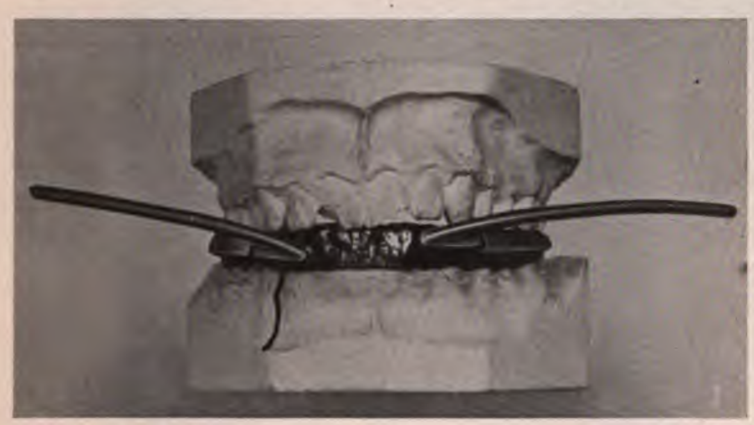

Fig. 495.—Metal dental splint with arms for counter-pressure by means of bandages passing beneath the lower jaw.

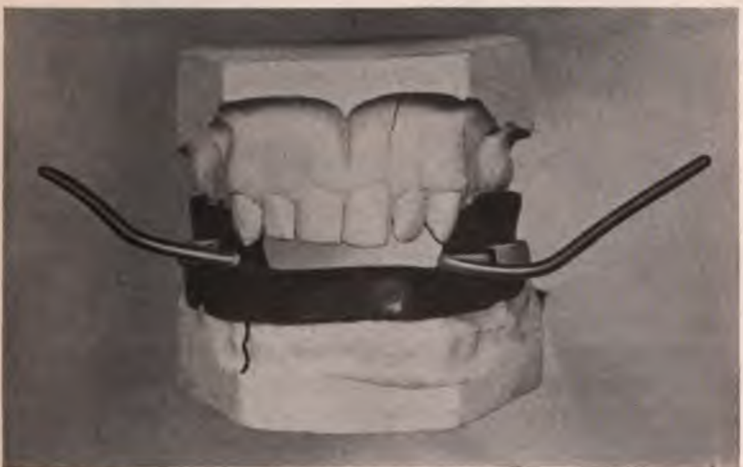

Fig. 496.—Vulcanite splint with arms for counter-pressure.

materials, and the technique of production will vary accordingly.

Ackland's splint consists of a metal gutter partly filled with gutta-percha which when softened takes the imprint of the lower teeth. The intraoral portion of the apparatus is held in position by means of clamps which make counter-pressure beneath the chin.

The Matas splint (see Fig. 497) consists of an adjustable clamp to be applied to the lower jaw. The intraoral arm carries a block tin form which is trimmed and bent to fit the teeth while the lower arm carries a perforated, adjustable, aluminum chin piece for counter-pressure. The intraoral block tin form is notched to facilitate bending and fitting to the teeth; this gutter may be filled with gutta-percha or dental composition to obtain more firm and accurate contact between teeth and splint. This splint will give very satisfactory results in the usual fracture of the body and may be applied with little difficulty.

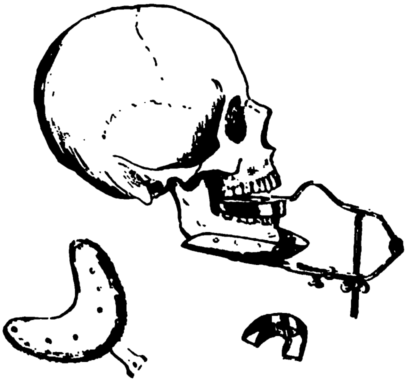

Fig. 497. The Matas splint. An excellent apparatus for the treatment of certain fractures of the lower jaw. This splint is adjustable and is supplied with different sizes of chin plates and dental splints.

The three splints just described together with the one following have the common advantage of allowing motion of the lower jaw during the after-treatment. Soft food may be masticated after the first few days and the patient has little difficulty in talking. The splint possessing these advantages in the greatest degree is the following:

4. *Dental splint cemented to the teeth.* (Heath.)

This splint is made of metal according to principles similar to those just described in producing the vulcanite splint. The dif-

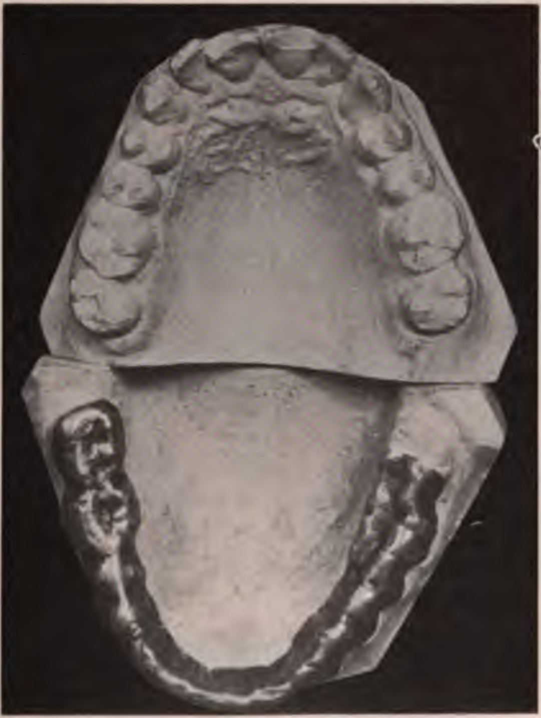

Fig. 498.—Metal dental splint for cementing to the lower teeth.

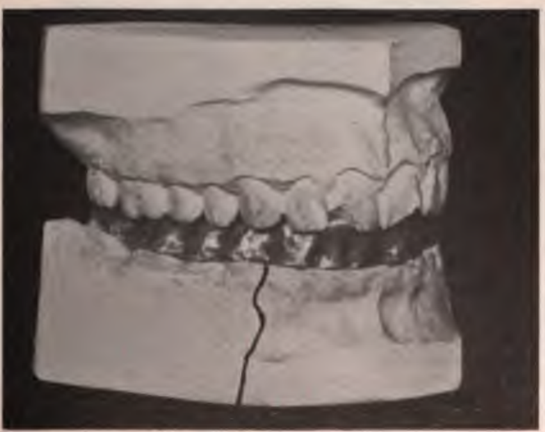

Fig. 499.—Same splint with the teeth in occlusion. In placing this splint in position the greatest care should be exercised to see that both splint and teeth are thoroughly dry, as otherwise the cement will not hold. The mucous surfaces are walled away with sheet cotton.

ference in material, however, will necessitate an altered laboratory technique, which is as follows: plaster casts of the two dental arcades are made and the deformity in the lower one corrected as described under heading No. 2, page 359. The cast of the lower denture is built up so as to do away with all undercuts, after which it is shellacked, dusted with soapstone and demounted from the articulator. A counter-impression is next made from it in oiled sand and the die formed by filling this sand mould with molten zinc. After cooling the die is removed, inverted in the moulding flask and packed about with sand so that the tips of the teeth alone are exposed. Molten lead is then poured into the flask to form the first or shallowest counterdie. Three or four counter-

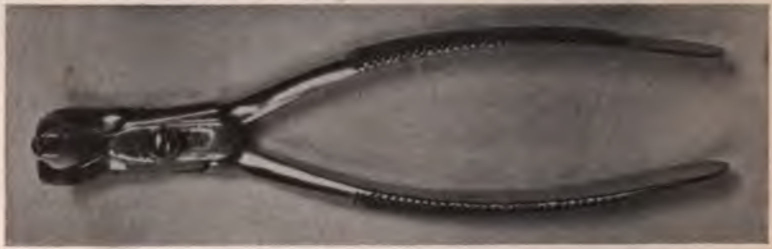

Fig. 500.—Edmund's forceps for clamping metal splint to the bases of the teeth. Slipping of the instrument and injury to the gums and alveolar process is prevented by the set-screw between the jaws which engages the crown of the tooth.

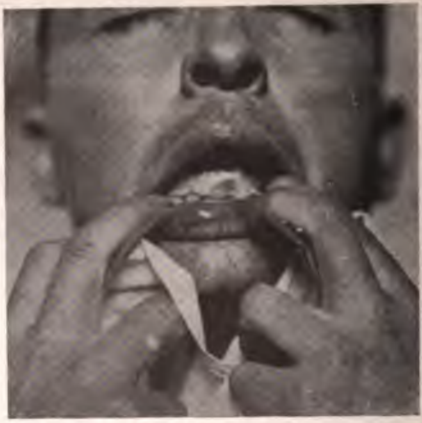

Fig. 501.—Cast aluminum splint cemented to the teeth for the fixation of a fracture of the lower jaw at the symphysis. In making this splint the patient's "bite" was taken in wax and the splint made from this so that the upper surface occludes with the upper teeth. Lack of occlusion between the splint and the upper teeth is uncomfortable and annoying to the patient during the after-treatment.

dies of graded depths should be made. This is accomplished by lowering the level of the sand in the flask, thus exposing a greater portion of the die to the molten lead. The splint is made by swedging metal between the die and counterdie. The most shallow counterdie is used first to start the metal of the splint, after which the deeper counterdies are used in order until by means of the deepest or complete counterdie the metal of the splint is forced into perfect form. Aluminum, silver or gold may be used in making the splint. After swedging is completed the splint is trimmed so that the edges will not impinge on the gums or cut the tongue. The final step consists in polishing, after which the splint is ready for use. The hollow side of the splint is then filled with cement and forced onto the teeth, care being taken to prevent the cement from being driven downward between the gums and teeth. The fixation of the splint to the teeth is rendered more secure by the use of Edmund's forceps (see Fig. 500) before the cement sets. This instrument is used to clamp the splint about the bases of the teeth, the set screw preventing the sharp jaws from slipping down onto the gums.

This splint fits the crowns of the lower dental arcade and is attached to them by means of oxophosphatic cement which requires about one-half hour to become firmly set. During this time displacement is to be guarded against by firmly holding or binding the lower jaw to the upper. This method requires considerable laboratory technique but when the patient has a good set of teeth to fasten the splint to, the method is probably the most perfect known. It is neat, efficient and allows easy cleansing of the mouth together with free motion of the jaw during the after-treatment. There are no bandages about the head and no clamps beneath the chin so that the patient is able to go about in public without being an object of curiosity. If wounds of the face accompany the fracture they may be treated without disturbing the fixation of the fragments.

5. *Wiring the lower jaw to the upper.*—This is a method which has the disadvantage of not allowing motion of the mandible during treatment and renders feeding and cleansing of the mouth more difficult. On the other hand it secures good occlusion and does not require any special, complicated apparatus or laboratory technique for its employment. The question of apparatus or the assistance of a dentist is not a hindrance in large cities but when

the surgeon is called upon to treat the condition without these aids he will find that wiring together of the jaws, if properly carried out and due care exercised in the subsequent cleansing of the mouth, will meet the requirements in most cases and is productive of the very best results.

The danger of vomiting during the time the jaws are wired together should be constantly borne in mind, and the patient must be provided with wire cutting pliers so that the jaws may be promptly released at any time. For the same reason an anesthetic must not be used in reducing the fracture if this method of immobilizing the fragments is employed.

The details in the technique, of wiring the lower to the upper jaw, vary with different surgeons but the essentials are the same.

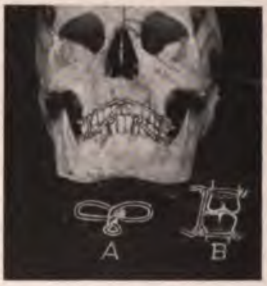

Fig. 502.—Oliver's method of wiring the lower to the upper jaw. *A*. shows the loop about the upper centrals. *B*. shows the manner in which the loops are attached to the molars.

Whatever method is employed we may expect the wire to stretch during the after-treatment and the torsion strength of the wire used must be sufficient to stand the additional twisting without breaking. The method described by Oliver is probably as satisfactory as any and has the advantage of preventing, equally well, both lateral and perpendicular motion. The method is as follows;—"for purpose of illustrating the method let us suppose a case with simple fracture slightly transverse through socket (distally) of right first bicuspid and mental foramen, slight deformity, articular plane deranged, long anterior fragment drooping somewhat and short posterior fragment drawn slightly upward and inward—the typical picture. The mouth is first thoroughly cleansed with hot antiseptic wash and swabs, the location and extent of fracture determined and the fragments adjusted and articular plane restored. Then a piece of soft drawn copper wire, about four inches long, previously annealed and sharpened at each end, is inserted from without inward between the right lateral and cuspid, is pulled through about half its length, burnished lingually to cuspid and then inserted from within outward between cuspid and first bicuspid, pulled through buccally again, where it is held. The other end is now brought back and inserted at the latter interproximal space, pulled through taut, burnished lingually to first and second bicuspid, carried back across line of fracture, inserted from within outward between first molar and second bicuspid, pulled through buccally again, brought forward taut across line of fracture and twisted with remaining ends at a point opposite an interproximal space. The adjustment of contour and articular plane is now verified; after which the ends tightly twisted, bringing firm traction through axis of each fragment across line of fracture which temporarily will hold the parts in their exact position. The twisted ends are clipped off, leaving a stub about an eighth of an inch long; this stub is turned upward and inward, entering the interproximal space far enough to prevent it from injuring any soft tissues with which it may come in contact. Immobilization is next accomplished by wiring lower to upper teeth, while occupying normal occlusion. This is done by the following original method, which insures against the possibility of any mobility, either lateral or perpendicular; first an anchor loop is made by taking a six-inch piece of annealed soft drawn copper wire, 20 gauge (B. & S.), bending it in the middle around a small-sized mandrel about one thirty-second of an inch in diameter, and twisting tight by one full turn with flat-nosed pliers (the twist may be strengthened by "tacking" together with a small bit of hard solder). The two long ends are now straightened out and placed parallel to one another, one end being snipped off one-fourth of an inch shorter and both ends pointed. They are now inserted from without inward, between the two superior central incisors, pulled through taut until loop rests, horizontally, firm against both teeth at the mesocervical border. Each end is now carried laterally from median line, burnished, respectively, to lingual surface of each central, and inserted from within outward between its respective central and lateral, pulled through firmly, brought forward to median line, above loop, and twisted tightly together, clipping off and turning stub into interproximal space as before noted. This forms a solid, permanently fixed, median anchor loop from which counter-traction may be had from each lateral half of the mandible for support and prevention of lateral mobility. Four pieces of the same wire, about three inches long, are in turn bent around the mandrel as before cited, forming the loop about one-third distant from one end and the long end sharpened. These lateral anchor loops are placed around solid teeth, one on each side, usually first molars or second bicuspids, in both upper and lower jaws, and serve as anchorages for the traction wires, one for each side. These traction wires threaded through all the loops commencing with the median, then the superior lateral, then inferior lateral and finally twisted with outer end midway between inferior lateral and median loop, exert a firm and constant pressure between upper and lower jaws and at the same time maintain counter-traction laterally. The twist is clipped short and may be turned upward under upper teeth. The lateral loops are positioned by inserting long ends into mesoproximal spaces of the respective teeth selected, pulled through taut until loop rests horizontally against cervicoproximal border, then carried backward, burnished to lingual surface, inserted from within outward at distoproximal space, pulled through firmly and twisted to outer end as near the latter proximal space as possible in order that the increased size of twist, being too large to pull back through space, will prevent the anchorage loop turning under stress of subsequent traction and also that the twist may be clipped off and turned into the space as above shown. The traction wires are about seven inches long, of same material, and should be annealed before being used. Care should be exercised to keep each one perfectly straight between loops and pulled taut in passing through each loop. When properly placed there will be a triangular geometrical figure with its first "stretch" a long horizontal line from median to superior lateral loop, a short perpendicular line from the superior to the inferior lateral loop and a long slanting diagonal line from inferior lateral to median loop, in which the twist has been made. With these heavy traction wires firmly fastened from each side of the jaw with teeth in normal contact, there is little likelihood of any kind of motion between either the fragments or the jaws. Should a wire break or become ineffective from being stretched, a very firm occipito-mental bandage is applied and both traction wires cut and removed. The anchorage loops are now tightened and new traction wires applied as before."[1]

The technique of simple wiring of the jaws together is less complicated than Oliver's method, but lacks some of its advantages. It is accomplished by passing loops about the teeth as shown in Fig. 503. The ends are twisted together to obtain a firm hold on the tooth and fastened with a similar pair of twisted ends which are secured to a tooth in the opposite arcade. With this method it may be necessary to replace the loops about the teeth if the wires break by twisting, or if it becomes necessary to cut the wires in case of vomiting. Moreover the fixation is not

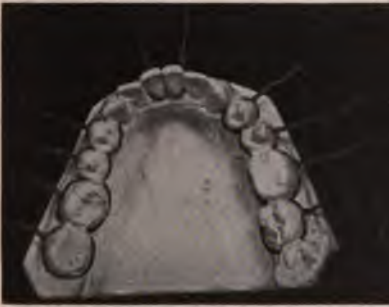

Fig. 503.

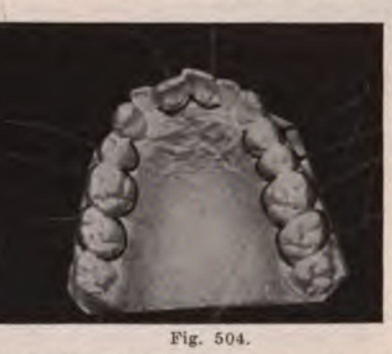

Fig. 504.

Fig. 503.—Loops of wire passed about teeth of lower jaw preparatory to wiring the jaws together.

Fig. 504.—Loops of wire passed about the upper teeth corresponding to those shown in Fig. 502.

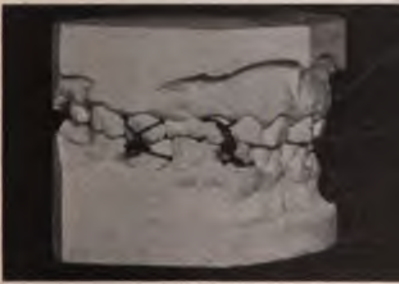

Fig. 505.

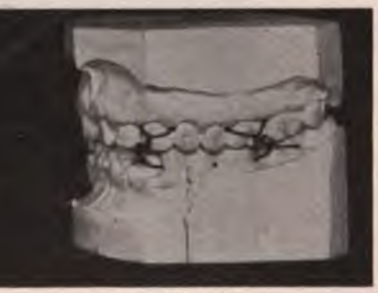

Fig. 506.

Fig. 505.—Two points of fixation in wiring the maxillæ together.

Fig. 506.—Opposite side in same case showing line of fracture and two additional points of fixation.

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[1] R. T. Oliver, D.D.S., *Jour. Amer. Med. Assn.*, Apr. 9, 1910.

quite as secure as Oliver's method and it is not possible to release the jaws as quickly in case of emergency.

Angle's bands and wire.—In place of the anchor loops described in Oliver's method we may employ Angle's bands such as shown in Fig. 510. They are ordinarily used in orthodontia but serve the purpose in fractures very nicely. They may be obtained at dental supply houses and the knobs for securing the traction wire may be attached to the band at any point desired by means of solder. Loops instead of knobs are sometimes used on the bands and are very satisfactory. Threaded bars and jack-screws are made to pass from an Angle band on one of the lower teeth to be anchored on a band placed on one of the teeth in the opposite arcade, but these should never be used since the jaws cannot be released quickly with wire cutting forceps in case of emergency. The Angle splint will be considered under the next heading.

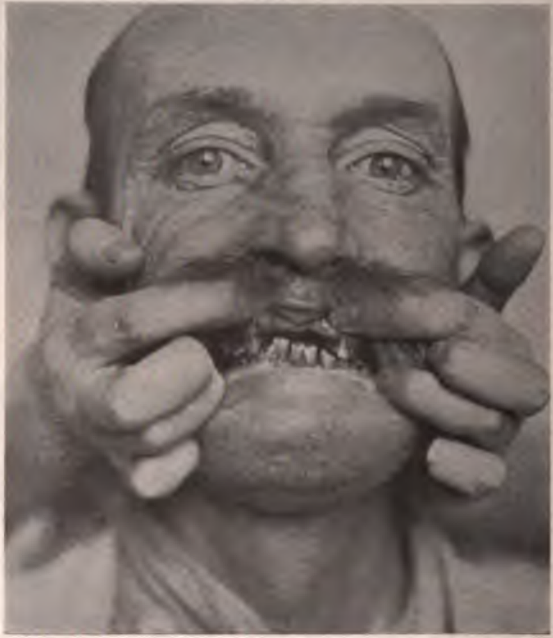


Fig. 507.—Simple method of wiring the upper to the lower teeth in fracture of the lower jaw. This is the same method as demonstrated in Figs. 503, 504, 505 and 506. Fragments held in good apposition in spite of dental deficiencies.

6. *Securing the fragments by means of wiring the teeth of the lower jaw.*—Various modifications of this principle have been

devised and in many instances the method is thoroughly satisfactory. An extremely old and sometimes efficient method is that of wiring the adjoining teeth. A loop of heavy wire is passed about four teeth (two on either side of the fracture) and the ends twisted tightly together, cut off and bent inward between the teeth so as not to injure the mucous membrane. It is usually difficult to get this wire sufficiently tight by twisting and when such is the case a racking wire is passed between the teeth so as to include both arms of the loop. The ends of this wire are twisted tightly together and in so doing the internal arm of the loop is snugged up against the lingual surface of the teeth. The wire must include at least two teeth on each side of the fracture; if only one tooth on each side is included they will almost surely loosen, the object of fixation thus being de-

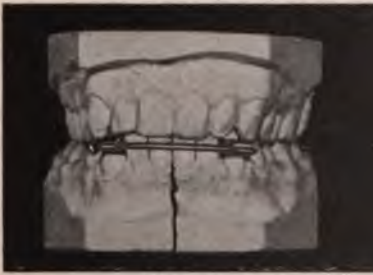


Fig. 508.

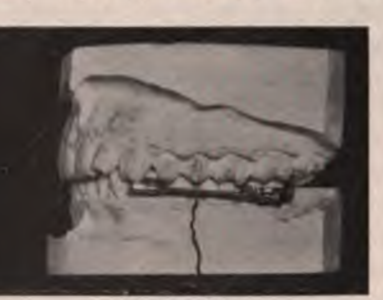


Fig. 509.

Fig. 508.—Angle's bands and bars applied to fracture of the mandible at the symphysis.

Fig. 509.—Angle's bands and bars applied to fracture of the mandible between the second bicuspid and first molar.

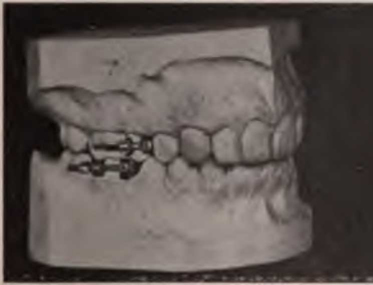


Fig. 510.

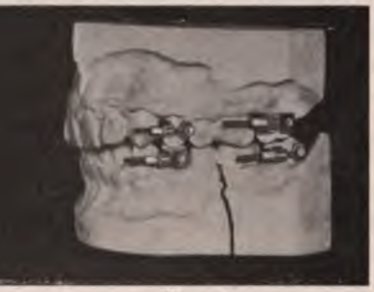


Fig. 511.

Fig. 510.—Angle's bands with knobs for wiring jaws together.

Fig. 511.—Same case as shown in Fig. 510 showing opposite side of jaw with points of fixation on either side of fracture.

feated. A more secure method of wiring the teeth together is described by Oliver in the first part of his procedure (page 367). Any form of wiring must be closely watched and tightened to compensate for the loosening which is sure to take place. For this reason silver wire is not as satisfactory as some other forms on account of the likelihood of its breaking when much twisting is required. Bronze-aluminum wire of large caliber or ordinary electric wire, with the insulation removed, may be used. In any event the wire should be heavy and the ends pointed to facilitate its passage between the teeth. If it is desired to pass wire between the teeth where there is not sufficient space an opening may be made slightly below the gums by puncturing with a sharp instrument; this however is very rarely necessary. Wiring will have to be varied according to the nature and disposition of the teeth. When there is much tendency toward lateral displacement this method should not be employed; it is particularly inefficient when the line of fracture through the body is oblique, so that one fragment tends to slip past the other.

Hammond's wire splint, a method which has been followed by good results, consists of a heavy iron wire encircling all the teeth. One continuous wire follows the lingual and buccal surfaces of the lower dental arcade. This wire should be heavy enough to withstand the lateral strain and after fitting it to the teeth it is better to remove it and solder the ends together rather than to depend on simple twisting. With the wire in place about the lower denture a number of copper racking wires of lighter material are passed between the lingual and buccal arms of the splint and the ends twisted to secure the appliance in place. Edmund's forceps (Fig. 500) may be used to force the heavy wire of the splint more snugly against the cervical portions of the teeth and to facilitate tightening the racking wires. This method is usually not secure enough to allow motion of the jaw during the after-treatment but should be used in conjunction with some method of fixing the jaws together.

Angle's splint consists of bands fastened about the teeth with a threaded bar passing between them. The bands are similar to those used in wiring the jaws together but have heavy tubes soldered to them instead of the knobs. The tubes are placed horizontally on the buccal side and have a heavy threaded bar passing through them from one side of the fracture to the other.

When the nuts are placed and tightened the fragments are pulled together and held in firm apposition. The splint may be tightened by passing wire from band to band on the lingual aspect.

Fracture of the ramus is a rare condition and is not, as a rule, accompanied by much displacement. Some form of fixing the jaws together will afford the necessary rest for the ramus and will be followed by good results in most cases. When much deformity exists open incision may be indicated to effect reduction. Wiring of the fragments may be called for if there is tendency toward displacement when the jaws are fixed. Fracture of the neck of the condyle, like fracture of the ramus, requires fixation of the jaws, and may require operative intervention if the displacement is pronounced. In operating in this region care must be exercised to avoid injury to Stenson's duct and the facial nerve (see Anatomy, page 350). Fracture of the coronoid is extremely rare and will probably require only fixation of the jaws for a short time.

Operative Treatment.—In some cases it may seem advisable in meeting the requirements of the case in hand to unite the fragments of the body of the bone by direct wiring or by the use of a small Lane plate. This is done through an incision parallel to and slightly below the lower border of the jaw. In making this incision care should be taken to avoid the facial artery which crosses the external surface of the bone in an upward and forward direction at the antero-inferior angle of the masseter. The bone having been exposed, holes are drilled in the positions of greatest advantage and wire passed, twisted, cut off and turned in. In oblique fractures with overriding tendency it is often best to have both arms of the loop passing through the plane of fracture in the substance of the bone. In transverse fractures a single loop with one arm on the external and the other on the internal surface of the bone will be sufficient to secure immobilization if the serrated edges of the fragments are well engaged and the wire properly tightened.

It is well in any operative procedure about the jaw to refrain from removing loosened teeth and spicules of bone unless entirely separated from the surrounding tissues, since they usually become solid as a result of the free circulation in this region. In some cases of fracture of the jaw we have actual destruction of a considerable portion of the bone, and in other cases we have loss of osseous tissue through infection and necrosis and in such instances it is difficult to obtain an end result which is perfectly satisfactory. When a portion of the bone is lost good occlusion is not possible and more or less deformity is bound to ensue unless some method other than those previously described is resorted to. In these cases much good can be accomplished by means of bone transplantation, although the method has not been sufficiently employed at the present time to state definitely what its limitations may be. However transplantation is justified and indicated, in view of the unhappy results following destruction of a portion of the jaw.

The bone transplant is usually taken from some other portion of the patient's skeleton and placed in the mandible according to the principles of bone transplantation laid down in Chapter LX.

The usual rules governing union in fractures do not hold good about the face since the free circulation is capable of withstanding greater insult and accomplishes great, rapid and extensive repair. Cases have been reported in recent years showing excellent results following transplantation of bone and what is still more surprising the formation of new bone about metallic framework previously built to fit the requirements of the case. This metallic framework has even been successful in the forming of a new condyle. The transplant is most easily and satisfactorily obtained from the crest of the tibia; it should be cut to accurately fit the deficiency in the jaw. Its ends must be placed in firm apposition with the freshened, living ends of the maxillary fragments and should be immobilized by wire loops or plates. The transplant must not be exposed within the mouth but should be protected at least by mucous membrane. Transplantation should not be performed in the presence of infection; it is essential to wait until all dead bone has sloughed out or been removed and the sinuses healed in, before the transplant or any other foreign material is introduced. In closing the incision after operation on the jaw a subcutaneous suture should be run, gathering in considerable tissue between the bone and the skin; by this means we will avoid the unsightly retracted scars so frequently seen following operations on the jaw.

The skin is best closed with horse-hair. If suppuration follows the operation we must see to it that drainage is free and complete but we should not be too hasty in removing foreign materials, since discharging sinuses in this region frequently close of themselves in spite of the presence of foreign bodies such as suture materials, plates, etc.

After-Treatment.—The after-treatment of fracture of the jaw consists in keeping the mouth clean by means of mild antiseptic washes and seeing to it that the mechanical appliance in use is properly accomplishing its purpose of immobilizing the fragments. When a method is employed which keeps the jaws closed the patient must be fed with liquids; an aid to the introduction of food will be found in passing a tube between the cheek and the teeth, the end passing behind the last molar. Eggs and milk will form the main part of the diet. These may be combined in different ways and various flavoring materials used to prevent the patient tiring of them. Soups and broths will add variety.

It will usually not be necessary to keep the jaws together for a period longer than ten days or two weeks so that the inconvenience of feeding is not a long one. Union is well under way by this time but the mandible will not be in condition to stand any considerable strain until two months or more have elapsed from the time of fracture; the patient should be cautioned in this regard.

Prognosis.—The usual case of fracture of the body of the jaw should be followed by perfect function and no deformity. Cases in which the trauma has been severe and in which there have been multiple fractures are much more difficult to treat and accordingly are sometimes followed by more or less loss of function and deformity. Protracted cases and those in which infection has occurred may be followed by damage to the articulation and in some instances ankylosis. The more complications the case presents the worse the prognosis.

CHAPTER XXIX.

DISLOCATIONS OF THE JAW.

Surgical Anatomy.—The temporo-maxillary articulation possesses many anatomical features which should be understood before entering upon the clinical aspects of dislocations of this joint. It is a ginglymo-arthrodial joint. The interarticular fibro-cartilage, horizontally placed, divides the cavity within the capsule into two distinct articulations, each with its separate and complete synovial membrane. The function of the upper articulation is that of gliding, which is brought into action in the lateral grinding motions of the jaw, and when the chin is protruded. The lower articulation, between the cartilage and the condyle, has a purely hinge-like action, used in raising and lowering the mandible. The peculiar formations of the condyle and glenoid cavity are difficult to appreciate unless one examines these surfaces on the skull, preferably in a fresh specimen. The nature of the articulation permits only of forward dislocation unless fracture complicates the condition. Backward, outward and upward displacements have been described though they are extremely rare Backward dislocation may occur when fracture of the neck of the condyle exists, and upward displacements have been reported as the result of the condyle having been driven through the glenoid cavity.

The joint has practically three ligaments, the capsular, internal lateral and stylo-maxillary. The external lateral ligament is simply a thickening in the outer portion of the capsule, while the interarticular fibro-cartilage lies within the capsule and is continuous with it. The internal lateral ligament is entirely independent of the capsule, being attached above to the spine of the sphenoid and below to the lingula. The stylo-maxillary ligament extends from the tip of the styloid process to the angle of the jaw. The anterior portion of the capsule is the only ligament limiting anterior displacement of the condyle after it has ridden over the eminentia articularis.

Dislocation of the jaw is almost always the result of muscular action, although violence has been known to have produced the condition. A blow on the chin, or a forward blow on the angle of the jaw while the mouth is open is known to have caused the luxation. It has occurred in yawning, talking, singing, coughing and vomiting. Overaction of the external pterygoid while the jaw is depressed is responsible for the luxation. When the condyle has been displaced far enough forward to become engaged in front of the prominence of the eminentia articularis, it is held in displacement by spasm of the internal pterygoid, masseter and the posterior fibres of the temporal.

Etiology.—This dislocation occurs more commonly in middle aged persons and is more frequently seen in women than in men. It is usually the result of muscular action and rarely caused by violence.

Symptoms.—In the usual bilateral dislocation the mouth is opened widely, and the entire jaw displaced forward. Saliva drools from the mouth. Articulation is impossible, and when the patient attempts to talk he is almost unintelligible. Considerable pain is experienced during the time the condylar processes are displaced. In the unilateral dislocation the mouth is open, chin protruded and displaced to the opposite side, which gives the face a peculiar twisted appearance. The displaced condyle may be felt below the zygomatic arch and a depression exists just in front of the ear indicating the empty glenoid cavity.

Treatment.—Reduction is accomplished by forcing the rami of the jaw downward and backward as the body of the bone is raised. The thumbs are protected by a towel, or heavy bandages, introduced into the mouth and carried as far back as the last molars on either side, the opposing fingers then secure the lower border of the body of the bone. Downward and backward pressure is then made by the thumbs, forcing the condyles over the articular eminences as the body of the bone is raised. The thumbs should be removed before the molars come together. The spasm of the muscles previously referred to sometimes offers a most serious obstruction to reduction even to the extent of necessitating an anesthetic. It is surprising with what facility reduction may be accomplished with the muscles relaxed in cases in which the jaw seemed immovable in its displacement before an anesthetic was given. It is extremely rare to find a case in which reduction cannot be accomplished under anesthesia. If the displacement has existed for some months the formation of adhesions about the condyle and changes in the glenoid cavity may necessitate open incision to effect reduction. If necessary the condyle may be resected with a view to the formation of a new joint.

After-Treatment.—The jaw should be fixed for a period of two weeks following the accident. This is readily accomplished by means of a four-tailed or Barton bandage. The patient should be cautioned not to open the mouth too far for at least another month following the removal of dressings. When dislocation of the jaw has once taken place it is likely to occur again, and unless the patient is apprised of this fact he may feel that the treatment was not successful if luxation recurs even at a remote period.

Prognosis. Reduction is usually accomplished without difficulty in recent cases. Restoration of function is perfect with the exception of a tendency to habitual luxation which exists in all cases

CHAPTER XXX.

SCALP WOUNDS.

Wounding of the scalp is such a frequent and important complication of fracture of the skull, that the management of these wounds is best considered before entering upon the subject of injury to the skull and brain. Fracture of the vault of the skull is usually accompanied by wounding of the scalp or, in other words, the fracture is compound; and the successful treatment of the wound will often determine whether or not infection will follow the injury, and hence is of the greatest importance.

Surgical Anatomy of the Scalp.—The scalp is composed of five layers:

1. The skin.
2. The subcutaneous layer of fat.
3. The occipito-frontalis muscle and its aponeurosis.
4. The subaponeurotic connective tissue.
5. The pericranium.

These layers individually and collectively are of considerable surgical importance and should be understood when treating wounds of this region. The skin of the scalp, the toughest and thickest in the entire body, is supplied with numerous hair follicles and sebaceous glands. The subcutaneous layer of fat has bundles of fibrous tissue passing through it in all directions, and, together with the skin, is firmly adherent to the aponeurosis of the occipito-frontalis which lies directly below it. The hair follicles of the skin extend down into the subcutaneous tissue, and in gaping wounds the bulbous ends of the follicles may be seen by everting the edges. The aponeurotic layer or galea is composed anteriorly, of the frontalis muscle, which is inserted into the skin, posteriorly, of the occipitalis muscle, which arises from the superior curved line of the occipital bone, and the aponeurotic tissue or tendon which extends between these two muscles and divides the scalp surgically into two layers;—the superficial and deep.

Wounds which divide the aponeurotic layer will gape, while wounds which penetrate only to the galea will present approximated edges. Transverse wounds dividing the galea usually gape more widely than wounds of the same depth running in an anteroposterior direction. The three superficial layers just named are loosely connected with the deeper structures by means of an areolar tissue which allows free motion of the upper layers over the skull. The layer of subaponeurotic connective tissue is of the greatest surgical importance since infections in this loose areolar tissue, following the lines of least resistance, may spread, and if not promptly and freely drained the entire calvarium may be covered by the infection and the scalp "floated" with pus. The pericranium is the deepest layer, covers the calvarium and acts as a modified periosteum. It differs from periosteum in other regions in the following respects: the pericranium does not re-form bone following loss of osseus tissue to the extent observed in periosteum elsewhere; the circulation is less free; and it may be stripped from the bone without causing any serious disturbance in the nutrition of the denuded osseous tissue. Where the pericranium crosses the sutures it is intimately connected with the intersutural connective tissue, though in other portions of the skull it may be readily stripped from the bone. The scalp as a whole, together with the hair, affords an excellent protection to the skull and is richly supplied with blood vessels. The main portion of the circulation of the scalp runs in the subcutaneous connective tissue and in the skin itself, and its richness accounts for the remarkable reparative properties of the scalp, which are not equalled elsewhere in the skin of the body except the face. The amount of fibrous tissue present in the layer in which the blood vessels run accounts for the profuse and prolonged hemorrhage so common in scalp wounds. This fibrous tissue prevents the vessels from closing as they do elsewhere following injury, and explains the difficulty so frequently experienced in catching and ligating vessels in the scalp. The mobility of the scalp will often save the parts from wounding by allowing them to give before the vulnerant body.

VESSELS OF THE SCALP.—In the frontal region we have the frontal branch of the ophthalmic artery which emerges from the inner angle of the orbit and anastomoses with its fellow of the opposite side and with the supraorbital artery. The supraorbital artery is a branch of the ophthalmic, of larger size than the frontal. It emerges from the orbit through the supraorbital notch at the junction of the inner and middle thirds of the supraorbital ridge, and divides into superficial and deep branches anastomosing with the frontal and anterior branch of the superficial temporal artery. The side of the scalp is supplied by the superficial temporal, a branch of the external carotid artery, which may be palpated as it ascends just in front of the auricle. This artery divides into an anterior and posterior branch and anastomoses with the deep temporal arteries; the anterior branch of the superficial temporal anastomoses with the supraorbital, and the posterior branch anastomoses with the posterior auricular and occipital arteries. The deep temporal arteries are two branches of the internal maxillary; they supply the temporal fossa, anastomose with each other and with the superficial temporal and lachrymal arteries. The occipital and posterior auricular arteries,—branches of the external carotid,—supply the posterior portion of the scalp as far forward as the ears, and anastomose with each other and the posterior branch of the superficial temporal artery. The occipital artery passes onto the scalp at a point about midway between the inion and the external auditory meatus and in this region is more or less exposed to injury; when opened it may give rise to profuse hemorrhage. It may be temporarily controlled by compressing it against the skull on the proximal side of the wound. All of the arteries of the scalp may be temporarily controlled by the application of an elastic tourniquet about the head, which is kept in place until the main branches are secured with ligature. The arteries most likely to cause free hemorrhage are the occipital and superficial temporal, either of which may be controlled by digital pressure against the skull below the wound. The anastomosis between the above named arteries is very free, and the size of the vessels is large for the region supplied; the result is that the blood supply to the scalp is great, and the vitality of the tissues correspondingly high.

The veins of the scalp correspond to the arteries just named, though there are some differences which are worthy of surgical note. The supraorbital vein anastomoses with the cavernous sinus by means of the angular vein near the inner angle of the eye, and thus infection in the region of the forehead may be drained into the cavernous sinus as well as into the facial vein, which is the communication of the supracranial corresponding to the arterial arrangement in this region. The superior longitudinal sinus receives blood from outside the skull by means of the vein which passes through the parietal foramen, and in like manner connection is established between the scalp and lateral sinuses through the mastoid and posterior condyloid veins. These anastomoses are of importance in showing the way in which infection may pass from the outer surface of the skull to the intracranial sinuses.

The lymphatic vessels form a free anastomosis in the scalp from which are derived the main trunks which follow the course of the arteries. The anterior portion of the scalp is drained into the submaxillary glands; the temporal region and that portion of the scalp above it is drained into the superficial and deep parotid lymphatic glands. That portion of the scalp lying behind a vertical line connecting the two external auditory meati is drained into the occipital and posterior auricular glands.

The nerves of the scalp may be divided into sensory and motor. The sensory nerves are of cranial and cervical origin. The anterior portion of the scalp is supplied by branches of the fifth cranial nerve and extends upward to about the middle of the vertex. The posterior portion of the scalp is supplied by branches of the upper cervical nerves. The sensory nerves may cause considerable pain lasting over a long period of time if they become caught in scar tissue and may necessitate operation to afford the patient relief.

All the muscles of the scalp are supplied by the facial nerve; the occipitalis muscle sometimes receives additional filaments from the occipitalis minor nerve. The upper branch of the "pes anserinus," supplying the frontalis, is the most frequently injured motor nerve in the scalp. Inability of the patient to wrinkle the corresponding half of the forehead should lead to a search for the divided ends of this nerve before a scalp wound of this region is closed.

Pathology and Symptoms.—Wounds of the scalp may be classified as incised, punctured, lacerated and contused; the nature of the wound depending on the character of the vulnerant body and the degree of trauma causing the injury. In addition we may have a simple contusion without an opening or wound in the scalp, and although it cannot properly be considered as a scalp wound yet its importance requires consideration under this heading. *Simple* *contusion of the scalp* is common and may lead to collections of blood or serum in any of the various layers of the scalp. When the collection of blood is in the movable layer of the scalp (i. e., above the galea) it will be found to be freely movable with the skin and quite circumscribed. When the fluid is below the galea it is not movable, is much more diffused and may present a circumference of induration which, when palpated in connection with the softened centre of the effusion, gives one the sensation of a depressed fracture. Continued digital pressure on this margin of induration will usually cause the fluids to be displaced sufficiently to differentiate, but if this is not satisfactory a needle may be used or the parts incised.

Effusions below the epicranium are rare except in infancy; when they do occur they will be found limited to one cranial bone of the vault, since the fusion of the epicranium with the intersutural fibrous tissue stays the further spread of the blood. Birth trauma and the free vascular connection between the epicranium and the skull in infancy accounts for the comparative frequency of such effusions (cephalhematomata) during that period.

The incised wound, strictly speaking, is caused by some object with a sharp or cutting edge, yet there is a distinction which must be made between a truly incised wound and an apparently incised wound which has been produced by some blunt instrument, such as a club. A scalp wound produced by a club may, to the inexperienced, have all the characteristic appearances of an incision, though on closer inspection it will be found to have a slightly ragged and contused edge and the underlying structures will not be found divided as by a knife. The cause of wounds has an important medico-legal significance, and when the attending surgeon is called upon to give testimony he should be aware of the close similarity existing between true incised wounds and those made by a dull instrument. The mechanism of the pseudo-incised wound has been likened to the splitting of a kid glove, struck with a cane while the leather is stretched across the knuckle.

The punctured variety of wound in the scalp is produced by pointed instruments, and the fact that the depths of the wound are not easily inspected without exploratory incision accounts for the overlooking of injury to the underlying skull and brain in many instances. It should be remembered that the punctured wound has the traumatic energy distributed over a very small area and is therefore more likely to do damage to the underlying structures.

Laceration of the scalp may exist in all degrees, from a slight tear to a complete avulsion. The average scalp wound shows some degree of laceration and more or less contusion, so that for practical purposes wounds presenting these features are best considered under one heading. The tissues of the scalp may be torn and bruised in various ways, and the degree of injury ranges from the most serious to the most trivial; the important question in each case—so far as the scalp itself is concerned—is, what portion of the tissues injured has been damaged beyond recovery? This question can only be answered by a careful examination of the wound and an estimation of the circulation remaining in the ragged, mashed and torn edges.

Dirt, cinders, gravel, broken glass and various other materials may be ground into the wound and the surrounding scalp, and if allowed to remain will act as foreign infectious bodies within the tissues. Loose hair is a very common material found within the wound and when not removed is almost sure to be followed by suppuration.

A common form of lacerated, contused scalp wound is one in which the blow causing the wound has resulted in the traumatic death of more or less tissue, which will ultimately slough out if not removed at the time of operation. When the edge of the wound shows slight laceration union can often be expected even if the lacerated edges are not trimmed away, but when the laceration is severe and the edges mashed, we may look for more or less sloughing if this tissue is not removed, regardless of the presence or absence of infection. When the devitalized tissue is extensive it may become impossible to remove it and approximate the edges. Inflammatory reaction is much more pronounced in contused wounds than in simple incision or puncture. A type of injury frequently seen is one in which one side of the wound has been slid and separated from the underlying structures as the result of a glancing blow, and the pocket thus formed under the scalp often contains infectious materials which have been forced into the wound at the time of injury.

Complications and Sequelæ.—The complications may be grouped under three headings: hemorrhage, infections and conditions accompanying fracture of the skull and brain injury. Late complications or sequelæ are painful scar, aneurism of the scalp, deforming contractures of scar tissue, tumor formation in the scar (keloids and rarely malignancy) together with the late complications following brain injury.

Treatment.—The treatment of these wounds will depend on the conditions present in each individual case and it will be impossible to formulate the routine to be followed in all instances. A scalp wound may be present without any evidence of injury to either skull or brain, the patient not having suffered the slightest concussion, while on the other hand the scalp wound may be a part of a serious condition in which the skull is fractured, the brain injured and the patient in extremis. These extremes together with the intermediate conditions require the greatest acumen and surgical judgment so that we may not subject the patient to unnecessary operation on the one hand, and also avoid the overlooking of serious complications on the other. There are, however, some general principles which should be followed in the treatment of these wounds, though the relative importance of each will vary in different cases. They are as follows:

1. Control hemorrhage.
2. Prevent infection as far as possible.
3. Avoid the overlooking of complications especially of skull and brain.
4. Close the wound as far as may seem advisable, providing drainage when necessary.

1. *Control of hemorrhage.*—The nature and amount of hemorrhage will depend upon the character of the wound and the vascular structures divided; it may be arterial or venous, and may consist of a simple oozing or an active spurting. The hemorrhage may be surprisingly profuse, when some of the main arteries of the scalp are divided, and when such is the case the first step in treatment must be the control of this bleeding. When the artery is accessible it should be secured with hemostats for the time being, until the scalp has been appropriately cleaned; if the hemorrhage consists of moderate or slight oozing it may be neglected during the process of cleansing. In some cases it may become necessary to further open the scalp to expose the bleeding artery. In the most profuse hemorrhages we may secure temporary hemostasis by packing a gauze sponge into the wound and making firm pressure on it with the hand. In the case of hemorrhage from a single large

artery, such as the occipital or superficial temporal, we may compress the vessel against the skull a short distance to the proximal side of the wound pending the proper securing and ligation of the bleeding end. In extreme cases an elastic bandage may be used to encircle the head so that it passes just above the brows and ears and in this manner all the large vessels of the scalp will be compressed against the skull.

One of the most annoying forms of hemorrhage is that of a persistent oozing which continues even after the wound has been thoroughly prepared and is ready for the sutures. This oozing may come from the edge of the wound proper or it may come between the layers of the scalp in cases where the injury has been produced by a glancing blow and one side of the wound has been separated from the underlying tissues by "sliding." Such oozing is not, as a rule, dangerous in itself but if allowed to continue after the wound has been closed, will result in the formation of clots which can only favor subsequent suppuration. The drier the wound when closed (other things being equal) the more reason we have to anticipate prompt healing. Oozing may be checked in many ways; by the use of heat, pressure, styptics and sutures, or a combination of these. A method which will in most instances be found all that is required, is as follows: take a gauze sponge of appropriate size wrung out of hot salt solution, pack it into the wound and make firm pressure with the hand from two to three minutes. When the sponge is removed the wound surfaces will be found dry and will not begin to bleed again unless roughly handled. This procedure is best carried out just before closing the wound when the manipulations necessary to preparation have been completed. A solution of 1:2,000 of adrenalin may be used to advantage in controlling oozing but strong chemical styptics should be avoided because of the injury they do to an already traumatized tissue. Oozing from the edge of the wound, especially of the venous type, will almost invariably stop when the sutures are placed and tied. After the wound has been closed it is advisable as an additional precaution to make pressure from one to two minutes to prevent the continuation of oozing and to express any blood which may have collected under the closed scalp. When it is necessary to leave buried sutures within the tissues plain catgut will be found the best. If hemorrhage can be controlled without the use of buried sutures it should be done.

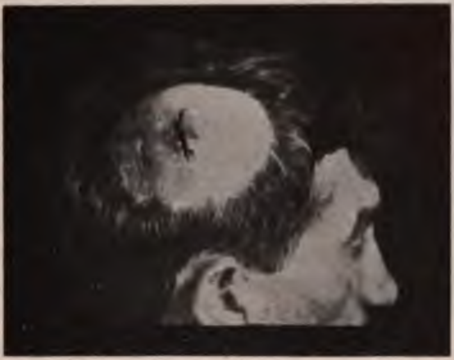


Fig. 512.—Ordinary scalp wound prepared for suture. Note the clean shaving of the scalp.

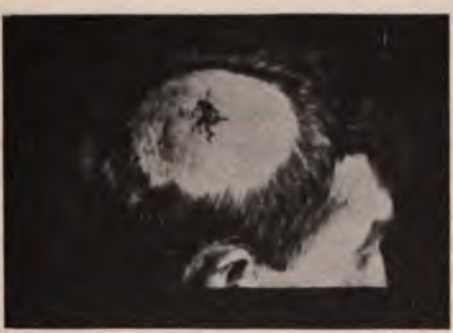


Fig. 513.—Sutures taken to bring the margins of the wound together.

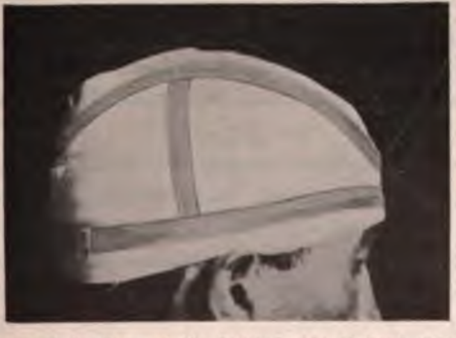


Fig. 514.—Recurrent bandage of the injured side of head with strips of adhesive applied to prevent slipping.

2. The *prevention of infection* is to be accomplished along lines similar to those already laid down under the "Treatment of Compound Fractures" (see page 789). Too much cannot be said in condemnation of the so-called antiseptics, such as bichlorid of mercury, which invariably do more harm to the already damaged tissues than they do to the germs of infection. The wound should be treated by attempting to remove the infection which has already gained entrance and not by killing it in situ. In other words we should endeavor to render the wound aseptic rather than antiseptic. It is of course practically impossible to remove all infection from the scalp, yet we may so reduce the number of bacteria present when the wound is thoroughly prepared that nature is enabled to dispose of those remaining without the formation of pus, in which case the wound is said to heal by first intention.

Crushed and devitalized tissue has no resistance and can serve no purpose within the wound except to act as a culture medium for infection and the same may be said of collections of dead blood. The indications therefore are to approximate healthy tissue and to avoid the extravasation of blood and serum within the wound. Clinically every scalp wound must be considered infected, yet we must not lose sight of the fact that additional infection and germs of different strains may be introduced within the wound by the surgeon, if aseptic regulations are not observed. The first indication in the treatment of scalp wounds (aside from the control of severe hemorrhage) is the shaving of the scalp surrounding the wound and the cleansing of the wound itself. Blood and dirt should be wiped away from the hair which is then clipped away for a distance of two to two and a half inches surrounding the wound. This region is next covered with lather and shaved, care being exercised to prevent the hair and dirt from entering the wound. After this has been accomplished the wound is irrigated with salt solution and the unshaved portions of the scalp dried with a sterile towel.

When the surgical surroundings are favorable an assistant should perform the preparation just described so that the surgeon may approach the prepared scalp with clean hands. If, however, the surgeon is treating the wound unassisted he should re-sterilize his hands and whatever instruments may have come in contact with the wound during preparation in order that the subsequent manipulations may be rendered sterile. The scalp is then once more irrigated in and about the wound and the surgeon is ready to explore the depths of the wound to remove infectious materials such as hair, felt, gravel, cinders, etc., and to trim away devitalized tissue. Isolated hairs show a strong tendency to cling to the inside of the wound and it is frequently necessary to pick them out individually with thumb-forceps even after the wound has been thoroughly irrigated and is supposedly clean. Tincture of iodine may be used on the surface of the scalp, either full strength or diluted, but is best kept out of fresh scalp wounds. Other antiseptics within the wound are not only useless but harmful and should not be employed.

3. *Detection of complications.*—After the hemorrhage has been controlled and infection prevented, as far as possible, the wound is ready for the sutures, but before these are placed the surgeon should satisfy himself that no symptoms of complications have escaped observation. The majority of scalp wounds may be explored sufficiently without incision to satisfy oneself as to the condition of the underlying skull, and when further opening of the scalp is necessary it is in most instances easily accomplished under local anesthesia. The local examination should be carried to a conclusion satisfactory to the surgeon and other symptoms of fracture of the skull noted when present. The ears and nose should be examined for hemorrhage and the eyes examined as to their position and pupillary reactions, the consciousness of the patient noted and the deep reflexes of the two sides compared. In other words, if fracture of the skull is present or suspected we should examine the patient for all the symptoms both local and general which are known to occur following fracture of the skull. (See symptoms of "Fractures of the Skull," page 411.)

4. *Closure of the wound.*—After the preceding three steps have been carried out the wound should be closed by interrupted sutures, preferably of silk worm gut, extending down to but not penetrating the galea. The question of drainage is a difficult one to settle and mistakes are sometimes made by those possessing the greatest experience. The greater the contusion or laceration the greater the probability that the wound will need drainage. If the patient can be kept under close observation following the closure of the wound it will usually be unnecessary to provide drainage, since pus can be detected and evacuated with little difficulty should it form within the wound. If, however, the circumstances are such

that the patient is not seen for a day or two following the first treatment, it is safer to provide drainage. When the drain is employed it should be placed in the most dependent position possible and when necessary counter-openings are to be made through the scalp and drains inserted. A rubber tube about the size of a thin lead pencil, sewed into the lower angle of the wound will be found a satisfactory form of drain. The wound may then be covered with gauze and a recurrent bandage applied to the head. When the wound is small the gauze dressing may be secured to the shaven scalp by means of collodion.

After-Treatment.—The most important element in the after-treatment consists of the detection of pus within the wound; the case should therefore be kept under close observation. The wound should be dressed and inspected at least once in twenty-four hours during the first week and if pus is suspected a fine probe, previously sterilized, in a flame, may be passed into one corner of the wound and the content, if present, evacuated. If pus does develop during the after-treatment, it should be thoroughly evacuated and openings maintained sufficiently large to allow free egress of the septic detritus. An infected wound should be freely drained so that granulation tissue will fill it from the bottom. The average clean wound will be solidly healed in ten days and the stitches should be removed on the eighth or ninth day. When the wound is infected the healing is much slower, sometimes lasting for weeks; during the treatment of this type of wound granulations may be stimulated by the use of balsam of Peru, and in some cases tincture of iodine painted over a foul granulating surface will render it clean and active in the course of a few days. The way in which iodine acts is uncertain yet excellent results follow its use in selected cases. The application of iodine to granulation tissue is quite different from its use on a fresh wound, where no special resistance has been developed, the circulation of the parts is not intact, and the vitality of the tissues reduced by trauma. When the loss of tissue is such that the scalp cannot be closed at the first treatment, skin-grafting should be resorted to if the defect is one which cannot be filled by granulation within the first two or three weeks.

CHAPTER XXXI.

FRACTURES OF THE SKULL.

The skull is the bony protection of the brain and when this protective wall is injured the brain is likely to suffer, at least indirectly. The brain may suffer injury from penetration of the vulnerant body, by pressure from depressed fragments, by exposure of its substance; by concussion, contusion, laceration, infection and degenerative sequelæ such as cysts and abscesses.

Fracture of the skull and injuries to the brain are distinctly different subjects, yet the frequency with which they are associated makes it necessary to consider them under one heading. If the bone lesion were all that we had to confront us in these cases the matter would be simple, but with the addition of injury to the brain it becomes one of the most complex conditions with which we have to deal. Any, all, or none of the symptoms to be enumerated may be present in a given case at the time of examination; accordingly fracture of the skull may be the easiest or the most difficult of conditions to diagnosticate. The proper treatment will usually depend on the proper diagnosis, and a proper diagnosis often calls for the most careful observation and consideration of every symptom present.

Fracture of the skull may be divided into three groups:

1. Those in which recovery would take place without treatment.
2. Immediately fatal cases, and those who live but a few hours (all treatment being futile).
3. Those whose lives can be saved or in whom serious sequelæ may be averted by proper treatment.

The last group is the one to which our attention is directed. It is however no simple matter to determine at the time of examination to which group a given case may belong. The unexpected is more common in head injuries than in other fields of surgery; an apparently slight injury may result in death while a case presenting grave symptoms may recover. There is no absolute means of avoiding mistakes in the diagnosis and treatment of these cases, yet careful observation combined with sound judgment,—the fruit of study and experience,—will reduce these mistakes to a minimum.

Classification.—Fractures of the skull have been variously classified and the terms used indicate the conditions without further definition. We have fracture of the vault, fracture of the base and fractures involving both vault and base. Fractures of the base may be classified according to the fossa involved. There are fissured fractures, depressed fractures, comminuted fractures, etc., the same terms being used as are applied to fractures in general.

Surgical Anatomy.—A knowledge of the anatomy of the skull and brain is essential to the proper interpretation of symptoms and the administration of treatment, but the subject is so extensive that it will be possible to consider briefly only the most salient features; the reader being referred to text-books on anatomy for more detailed accounts.

BONES OF THE SKULL.—*Development.*—The bones of the vault (tabular portion of the occipital, parietals, squamo-zygomatic portions of the temporals, and the frontal) are ossified in membrane from centers which appear at about the end of the second fœtal month. Ossification beginning in the center of a quadrilateral bone reaches the corners last and accordingly at birth we find the "fontanelles" which represent the unossified portions of the bones of the vault. These fontanelles are situated at the four angles of the two parietal bones and are therefore six in number. The four lateral fontanelles at the lower angles of the parietal bones are closed a short time after birth; the one situated at the junction of the sagittal and lambdoid sutures closes within the first few months of life; the one remaining, situated at the bregma, continues open during the first year. Although the process of ossification begins earlier in the vault of the skull than in the base, nevertheless, at birth, the base is far more completely ossified than the vault. The base is ossified in cartilage as is the rest of the skeleton. Wormian bones occur most frequently in the course of the lambdoid suture but are not uncommonly found in the fontanelles; the suture surrounding them may at first sight be mistaken for a linear fracture while exploring wounds of the scalp. In the aged the frontal, parietals and occipital are practically one continuous bone due to the ossification of the sutures between them; the basilar process is continuous with the body of the sphenoid and the lesser wings of the sphenoid are continuous with the orbital plates of the frontal. The lambdoid suture meets the sagittal suture at a point about two and a half inches above the inion. The center of the anterior fontanelle (the bregma) is at a point about one-fourth inch anterior to a vertical line connecting the external auditory meati. The intersutural fibrous tissue acts as a linear shock absorber which interrupts or reduces vibrations passing from one cranial bone to another. The bones of the skull are composed of two layers of compact tissue between which is interposed a layer of cancellous tissue known as the diploë or diploic layer. The outer layer is heavier, stronger and less brittle than the inner. The skull is by no means of a uniform thickness throughout, which fact may be nicely demonstrated by holding the base of the skull up against the light and noting the places which are translucent and those which are opaque. The thin regions are produced, to some extent, by obliteration of the diploë, and these areas of thinness and thickness are of importance in trephining and in estimating the probability of penetration in a given region. The thin places in the skull are the orbital plates of the frontal (supporting the frontal lobes), the squamous portions of the temporals (in contact with the spheno-temporal lobes) and the middle of the posterior fossa below the grooves for the lateral sinuses (which accommodate the cerebellum). At any of these places a well directed blow with a pen-knife could penetrate the skull and injure the brain. In contrast with the regions of thinness there are ridges which act as buttresses and serve to strengthen the skull. In the vault, they are situated as follows: the torus transversus occipitalis, a thickening in the bone extending laterally from the external occipital protuberance, a median thickening of the skull extending from the glabella to the foramen magnum and corresponding to the course of the superior longitudinal and occipital sinus, and the temporal crests ascending from the external angular processes of the frontal to be continued into the temporal ridges. In the base we have the ridges which divide the region into the three fossæ and notwithstanding the fact that they are composed largely of thin, brittle compact tissue, they serve nevertheless to reënforce this part of the skull. They are: the petrous portion of the temporal and the lesser wing of the sphenoid. The base of the petrous portion of the temporal is applied to the skull in a region which corresponds to the mastoid externally and accordingly this part is comparatively strong. The foramen magnum is also surrounded by a ridge which is a bifurcation of the internal occipital crest, the two divisions ascending anteriorly to the posterior clinoid processes. These thickenings in the skull all have more or less tendency to modify vibrations and hence, to stop or divert lines of fracture.

The foramina in the base of the skull are said to weaken it, and are of importance since the study of their positions and contents will aid in determining the location of the fracture. In the anterior fossa we have the cribriform plate of the ethmoid, the thinnest and weakest place in the floor of this fossa. It transmits the olfactory and nasal nerves, the latter passing through the nasal slit. In the middle fossa we have the sphenoidal fissure which transmits the nerves and vessels passing to the orbit: The motor occuli, abducens, patheticus, the three branches (nasal, lachrymal and frontal) of the ophthalmic and the sympathetic nerves as they pass from the walls of the cavernous sinus to the orbit. These nerves are accompanied by three vessels: The orbital branch of the middle meningeal artery, a recurrent branch of the lachrymal artery and the ophthalmic vein. The foramen rotundum and ovale in the same fossa transmit respectively the second and third branches of the fifth cranial nerve together with other structures of minor importance. The middle meningeal artery enters the skull through the foramen spinosum situated in the tip of the great wing of the sphenoid. Through the carotid canal we have the internal carotid artery entering the cranial cavity accompanied by the carotid plexus of the sympathetic, the latter being continued into the cavernous plexus when it reaches the side of the body of the sphenoid. The foramina in the posterior fossa are the foramen lacerum posterius or jugular foramen, the internal auditory meatus, the two condyloid foramina and the foramen magnum. The jugular foramen transmits the glosso-pharyngeal, pneumogastric, and spinal-accessory nerves; also the lateral and inferior petrosal sinuses and a small artery. The inferior petrosal and lateral sinuses join to form the internal jugular vein a short distance outside the skull. The anterior condyloid foramen transmits the twelfth cranial nerve and occasionally an artery, the posterior condyloid foramen transmits a vein which establishes communication between the lateral sinus and the deep veins of the neck. The internal auditory meatus transmits the facial, the auditory and the pars intermedia of Wrisberg, also a branch from the basilar artery. The gustatory fibres of the seventh join the nerve as it enters the internal auditory canal and leave it by way of the chora tympani.

MEMBRANES OF THE BRAIN.—The brain as it lies within the skull is enclosed within three membranes which conform more or less closely to its surface.

The dura, the most superficial of the three, is composed of tough inelastic tissue which acts as the internal periosteum of the skull and is richly supplied with blood vessels. Most of the nutrition of the bones of the skull is derived from vessels running in this membrane. The dura is composed of two layers, a superficial and a deep. The superficial, or vascular, layer acts as the endosteum while the deep layer is lined with endothelium on its deep surface, and dips down between certain portions of the brain to form partitions and give support. The dura as a whole is more firmly adherent to the skull in childhood and in old age than it is in middle life; it is more firmly adherent at the base and where it crosses the sutures than elsewhere. Sir Chas. Bell has demonstrated the possibility of separating the dura from the bone without opening the skull; "Strike the skull of a subject with a heavy mallet; on dissecting you find the dura mater to be shaken from the skull at the point struck. Repeat the experiment on another subject and inject the head minutely with size injection, and you will find a clot of injection lying betwixt the skull and the dura mater at the part struck, and having an exact resemblance to the coagulum found after violent blows on the head."

The reduplications of the dura extending into the cranial cavity between the main portions of the brain are three in number; between the hemispheres of the cerebrum we have the falx cerebri, between the lobes of the cerebellum we have the falx cerebelli, and between the cerebellum and the occipital lobes of the cerebrum we have the tentorium cerebelli. The venous sinuses run between the layers of the dura which go to make up these three infoldings. The tentorium, like other portions of the dura, is a tough, inelastic membrane and,—since its crescentic margin is firmly attached to the grooves on the occipital bone (the upper edge of the petrous portions of the temporal bones and the posterior clinoid processes),—it is more or less liable to be torn when the cranium changes form during the process of moulding, as it passes through the birth canal. Intracranial hemorrhage may then take place from the sinuses running between its layers. The falx cerebri serves to prevent the hemispheres of the cerebrum from jostling each other when the head is struck or moved quickly, and the falx cerebelli serves the same purpose for the two halves of the cerebellum. The tentorium cerebelli sustains the weight of the occipital lobes and prevents them from pressing on the cerebellum.

The pia mater is a delicate membrane which invests the surface of the brain, contains numerous small vessels which extend perpendicularly into the substance of the cortex. This membrane dips down into all the sulci, following the surface of the brain in every detail. It also forms the velum interpositum and the choroid plexus.

The arachnoid lies between the dura and the pia, is composed of a loose areolar tissue and divides the space between the dura and pia into the subdural and the subarachnoid spaces. The arachnoid dips into some of the larger sulci, but resembles the dura in this respect more than the pia. The thickness of the membrane varies considerably in different portions of the brain. On the cerebral hemispheres it is thin and delicate, while the part investing the pons is heavy and much less vascular. The subarachnoid space (between the arachnoid and pia) is quite large at the base of the brain and is filled with cerebrospinal fluid. The subarachnoid and subdural spaces connect with the ventricular cavities of the brain through the foramen of Majendie in the posterior medullary velum of the fourth ventricle. The cerebrospinal fluid by its escape into the spinal spaces allows a certain amount of displacement of the cranial content.

VESSELS OF THE MEMBRANES.—The vessels running in the dura are often partially accommodated by grooves on the inner surface of the skull, and this intimate contact between bone and vessel renders the latter quite liable to injury when the line of fracture traverses these bony channels. The most important artery in the dura is the middle meningeal, a branch of the first portion of the internal maxillary artery; it gains entrance to the skull through the foramen spinosum and passes outward onto the internal surface of the squamous portion of the temporal, where it divides into an anterior and posterior branch. The anterior branch passes outward and forward, while the course of the posterior branch is outward and backward. Both branches are continued onto the inner surface of the parietal bone. There is considerable normal variation in the courses of these two branches after they reach the parietal bone, and we have no possible means of ascertaining the exact position that they may occupy in a given case. The anterior branch, however, will usually be found passing upward and slightly backward from a point about one and three quarters inches above the zygoma and one and a half inches behind the external angular process of the frontal bone. The course of the artery from this point is nearly parallel to the coronal suture, running from one-half to three quarters of an inch behind it. A trephine opening with its center about one inch above the external auditory meatus will expose the posterior branch of the middle meningeal. In trephining in this region it should be remembered that the skull is thin, the internal surface irregular and that the anterior branch of the middle meningeal (especially in the region of the pterion) may run in a complete bony canal instead of a groove. Krönlein's diagram gives the three most frequent sites for the location of clots following hemorrhage from this artery. The diagnosis of the position of these clots is often difficult, sometimes impossible. The

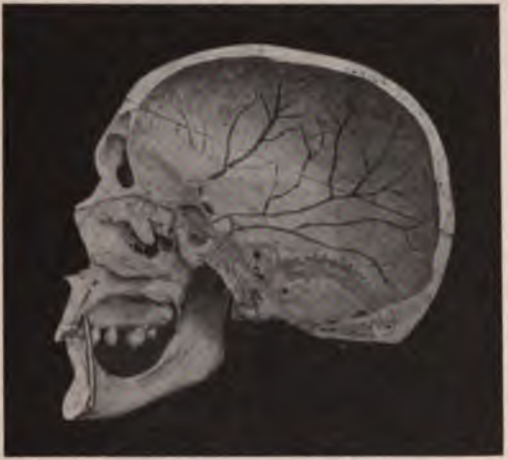


Fig. 515.—Internal surface of right half of skull showing courses of middle meningeal artery and lateral sinus. In this case the posterior branch of the artery is double and calls attention to the frequency with which anomalies occur in the course and distribution of this vessel. A study of this vessel and its anomalies will point out the advantages of the osteoplastic method of opening the skull as compared with trephining, for the removal of clots.

most satisfactory method has been found in the osteo-plastic flap which exposes enough of the brain to satisfactorily explore its surface without missing the site of hemorrhage. Meningeal hemorrhage may take place from some of the smaller meningeal arteries and occupy regions in the frontal or occipital lobes. A common form of meningeal hemorrhage is that arising from small veins. A linear fracture may divide small veins, and the resulting hemorrhage, though slow, not infrequently forms a large coagulum. In this form of hemorrhage the symptoms are slow in developing because it takes a number of hours for the clot to assume sufficient size to cause disturbance. In addition to the middle meningeal artery, there are also other meningeal arteries of smaller size. They are the three meningeals from the ascending pharyngeal:—the anterior meningeal from the internal carotid, the posterior from the vertebral, and the small meningeal from the internal

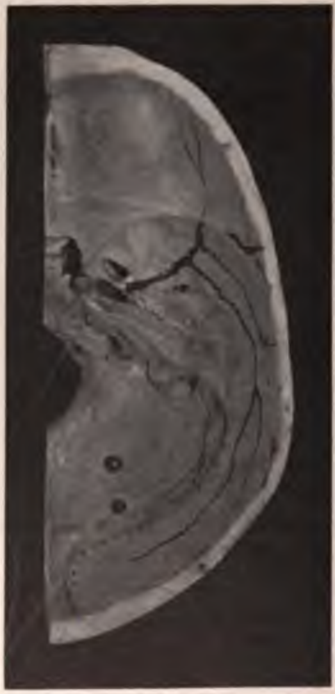


Fig. 516.—View of right half of interior of base of skull showing the courses of the middle meningeal artery and lateral sinus.

maxillary. These arteries, however, are all of small size and rarely the cause of hemorrhage.

INTRACRANIAL SINUSES.—The most common site of meningeal hemorrhage, after the middle meningeal artery, is the lateral sinus. The walls of the sinuses are formed by a splitting of the dura and are lined by an endothelial layer which is continuous with the lining membrane of the veins. Sinuses may be the site of thrombosis and suppuration and when ruptured result in intracranial hemorrhage; they should be specially avoided when trephining the skull. The superior longitudinal sinus corresponds to a line drawn from the glabella to the inion. A line drawn from the inion to a point one and a half inches above the external auditory meatus will correspond to the highest part of the lateral sinus where it crosses the lambdoid suture. The lateral sinus then curves downward and forward running on the internal surface of the mastoid portion of the temporal. It is joined by the superior petrosal sinus at the posterior end of the upper border of petrous portion of the temporal and by the inferior petrosal sinus just below the jugular foramen after the two sinuses have passed out of the skull. The two cavernous sinuses situated on either side of the cella Turcica drain the ophthalmic vein, anastomose with each other through the circular and transverse sinuses and are themselves drained into the lateral sinuses by means of the petrosal sinuses. A line drawn perpendicular to the surface of the bone just below the inion, if projected into the skull, would correspond to the course of the straight sinus. The straight sinus drains the veins of Galen and the inferior longitudinal sinus which runs in the lower border of the falx cerebri. The blood from the straight sinus is drained by one of the lateral sinuses after having been emptied into torcular Herophili. The occipital is formed by the two marginal sinuses which connect with the sigmoid portion of the lateral sinus; it passes upward and empties into the lateral sinus, the straight sinus or the torcular Herophili; it establishes connection with the deep veins of the neck through the foramen magnum. The origin, course and exit from the skull of the twelve cranial nerves is of importance in diagnosis but the reader will be referred, for this detail, to text-books on the subject.

Lesions of different portions of the brain will give different symptoms according to the function of the region injured. We may divide local injuries of the brain into injuries of the cortical centers and their tracts, and injuries of the base. For practical purposes we may divide the cortex into motor areas, sensory areas,

Fig. 517.

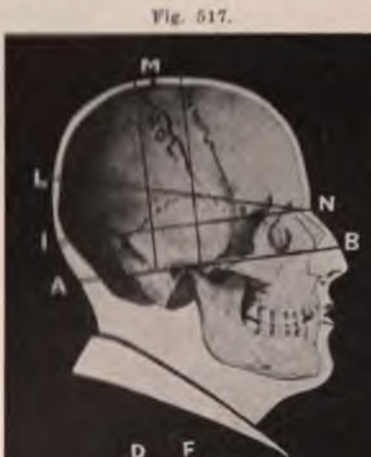
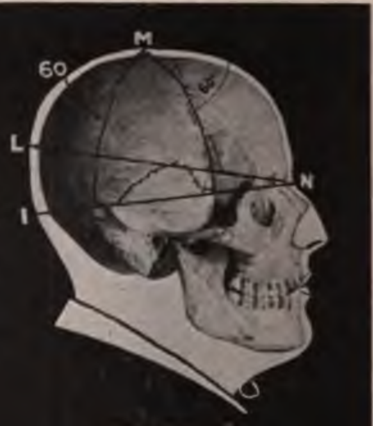


Fig. 518.



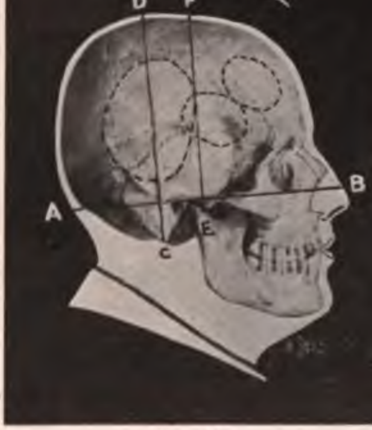


Fig. 519.

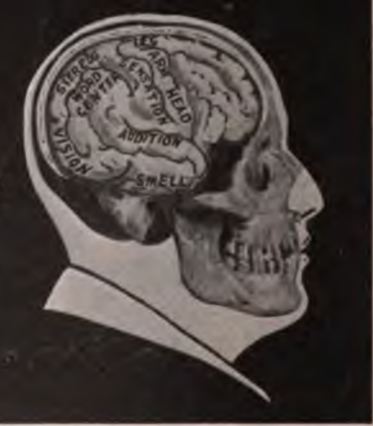


Fig. 520.

Fig. 517.—*M.*, Midpoint of naso-inionic line; *L.N.*, Poirier's line and corresponds to Sylvian fissure; *I.N.*, Kocher's equatorial line from nasion to inion; *A.B.*, German base-line and passes through inferior edge of orbit and upper border of external auditory meatus.

Fig. 518.—*M.*, *L.N.* and *I.N.* same as in Fig. 517. A line drawn forward and downward at an angle of 60 from median plane is known as Kocher's anterior meridian and lies over precentral convolution. Kocher's posterior meridian is drawn downward and backward 60 from the median plane.

Fig. 519.—Dotted areas correspond to the most frequent sites of meningeal hemorrhage.

Fig. 520.—Cortical centers.

and a number of so-called silent areas. The cortex of the brain is composed of gray matter which in most regions is disposed in five layers. Axis-cylinders from the cells of this gray matter establish communication between different portions of the cortex and between the cortex and the lower centers situated in the base of the brain and in the cord. The function of the cortex of the brain is to register memories of past experiences. Under certain conditions these centers are stimulated and have the capacity of reproducing the events which they have registered. Thus stimulation of the occipital lobe gives us the memory of sights seen, stimulation of the temporo-sphenoidal lobe gives us the memories of sounds heard, stimulation of the motor area gives us the memories of acts performed. It is therefore necessary to know what part of the cortex registers certain experiences in order that we may be able to tell just what symptoms would be produced by injury of a given part of the brain. Conversely, this knowledge having been obtained we may be able to state what part of the brain has been injured from the observation of certain symptoms. The cortex as has been said is divided into certain so-called centers. The frontal area is concerned with conscious selective action, the Rolandic area with motor memories and the reproduction of these memories which results in voluntary motion, while the spinal level is concerned with reflex and vegetative automatism. Experiment on lower animals and observation of diseased and traumatic conditions in the human being have determined the function of many regions of the cortex, but there are still many areas the function of which remains unknown. For obvious reasons the more complex and the higher the function of a given area, the more difficult it becomes to ascertain the nature of that function. The occipital lobe on either side of the calcarine fissure is concerned with the memories of sights seen; the temporo-sphenoidal, especially the left, with the memory of sounds heard and muscular memories; the left angular gyrus with the memory of written speech; the posterior part of the frontal lobe with the memory of printed speech; and the third frontal convolution on the left side is concerned with the memory of spoken speech. Stereognostic sense is located in the parietal lobe. The centers in the Rolandic sensori-motor area are disposed inversely (i. e., the centers for the head are below those for the upper extremity, etc.). The centers for the lower extremity extend onto the mesial surface of the hemisphere. Fracture of the vault may injure one or more of these areas. If the injury is slight, and the center is not destroyed, the lesion is said to be irritative and the center overacts.

If the lesion is more serious and the center is destroyed the function of that center is lost. Thus if the Rolandic area is irritated, the regions of the body supplied by the corresponding centers are thrown into unwonted activity or spasm; but if the lesion is more severe, function of the center is lost. This results in loss of memory for muscular movements and consequently they cannot be voluntarily reproduced. If Broca's convolution is destroyed, the memory for the acts connected with motor speech is lost and consequently the movements of motor speech cannot be reproduced. Of recent years, however, there has been some doubt as to the function of Broca's convolution, and it is not now thought to be so essential to speech as formerly.

If the lesion penetrates below the cortex, the fibres which associate these centers may be lacerated and the normal communication between centers is interfered with. Thus a given center cannot be stimulated, as in the normal person, by the activities of an associated center. If a center concerned with speech is destroyed and the function of that part of the cortex lost the patient is said to suffer from aphasia. If the fibres connecting a given cortical center with some other cortical center are lacerated the patient is said to suffer from intercortical aphasia. If the center destroyed is concerned with motor memories the patient has motor aphasia. If the centers concerned with registering purely sensory ideas are destroyed the patient has sensory aphasia.

The base of the brain also has centers distributed through its substance which preside over various important functions of a lower order than those found in the cortex. These centers have running through them fibres from the cortex of the brain, so that, in case of injury, we have not only symptoms of lesions in these lower centers but also symptoms of interruptions of impulses from the cortex.

In the anterior fossa we have the center for smell situated in the olfactory lobe. In the middle fossa we have the optic thalamus, the corpora quadrigemina, and the crus. The optic thalamus is concerned with emotional facial expression and lesions of this body may give rise to athetosis or incoördination of the paralyzed hand and pain in the paralyzed limb. The anterior corpora quadrigemina are associated with motion of the eyeballs and acuity of vision, the posterior corpora quadrigemina are related to hearing and equilibration. The crus contains the nucleus of the third and fourth nerves and longitudinal fibres passing from the cerebral cortex to the spinal cord. Lesions of this body give a characteristic set of symptoms in accordance with the nuclei and fibres contained within it: paralysis of the third and fourth nerves will deprive all the muscles of the eye of their nerve supply except the external rectus; injury to the longitudinal fibres may cause hemiplegia of the opposite side and hemianopsia may be present if the adjacent optic tract is injured by pressure. If both crura are damaged we have a double hemiplegia with paralysis of the third and fourth nerves on both sides, and in some instances optic neuritis. In the pons we have a continuation of the longitudinal fibres of the crura, the thermogenic center, and the nuclei of the fifth, sixth, and seventh cranial nerves. Injury to the fibres of the crura as they pass through the pons may produce hemiplegia, disturbance of the thermogenic center, extremely high temperature, and injury to the three cranial nerve nuclei will be followed by symptoms peculiar to each nerve. Injury to the nucleus with loss of function in each nerve will be as follows: for the fifth, hemifacial anesthesia with paralysis of the muscles of mastication; for the sixth, paralysis of the external rectus of the eye; and for the seventh, motor paralysis of the muscles of the face. Bilateral symptoms will be present if the lesion involves both sides of the pons.

The usual anatomical division of the bulb into pons and medulla is purely artificial. For practical surgical purposes they should be considered together.

The medulla resembles the pons and crura in containing longitudinal fibres from the cortex together with cranial nerve nuclei. The characteristic symptoms of lesions of the medulla will depend on the nuclei which it contains. In the upper border of the medulla is the nucleus of the eighth cranial nerve which also projects into the pons; in the lower half of the floor of the fourth ventricle we have the nuclei of the ninth, tenth, and eleventh cranial nerves and at a slightly lower level is found the nucleus of the twelfth. The vomiting center, the vaso-motor center and numerous other centers governing various functions in the body are situated in the bulb, but as yet too little is accurately known concerning them to be of considerable surgical value.

Further back in the posterior fossa we have the cerebellum which is concerned in coördinating the various muscular activities of the body and in the complex process of equilibration. Another function of the cerebellum consists in the peculiar power of imparting the proper degree of force to muscular movements. Injury to the cerebellum may give rise to cerebellar ataxia, obstinate projectile vomiting, and various forms of paralyses and anesthesias. The association of the cerebellum with the pons, medulla, basal ganglia and cortex is so complete that it is difficult to determine the source of these varied symptoms.

The foregoing enumeration is by no means complete as regards location and function of the cortical centers and basal ganglia; there is still considerable dispute concerning the functions of these centers and there are numerous other centers which as yet remain with functions unknown. There are many symptoms occurring in head injuries which could be properly explained if we knew more of the anatomy and physiology of the brain, but for the present the description given will be found of service in roughly determining the seat of injury in fracture of the skull.

Etiology.—Trauma is the cause of fracture of the skull but the nature and the degree of violence are so extremely variable that the resultant conditions show the greatest differences in detail. The trauma may be sustained over a small or large area of the skull; the vulnerant body may travel at a high rate of speed (bullet) or at a slow rate (club); the violence may be direct or it may be transmitted through the spinal column or inferior maxilla. The violence may be circumscribed or the head may be squeezed or crushed between heavy objects.

Fracture of the skull constitutes from four to six percent of all fractures and possibly more, since we are learning of recent years that the milder forms of the condition have only too frequently gone unrecognized in the past. Statistics are specially misleading in this particular injury, for the following reasons: in the first place the most severe cases never reach the hospital because of immediate death, and secondly the condition is frequently associated and confused with other injuries; thirdly, the milder cases are often successfully treated at home, and in many cases are not classified as fractures because of mistaken diagnoses. For these reasons figures derived from a service such as the police surgeon's will come nearer the truth, since it includes all classes of fractures ranging from the mildest to those immediately fatal. Occupation is an important element in the etiology. Fracture of the skull is most frequently found in the male and in middle life. The skull in the aged is much more easily fractured than that of the person in middle life, but on the other hand those advanced in years are not so exposed to injury.

Mechanism and Pathology.—The various ways in which the skull is broken, the manner in which fragments are displaced, and the region of the cranium involved have all been subjects of careful investigation, and terms, to designate the peculiarities of the conditions, have been applied. Before considering the mechanism of these fractures, it is necessary to again refer to the anatomy with respect to the peculiar formations of the vault and base. The structure of the skull is peculiar to itself and any attempt to liken the manner in which it breaks to that of other objects can at best be but incomplete. Circumscribed blows upon the vault of the skull commonly produce a local depressed fracture with or without injury to the underlying structures. A more extreme blow or squeezing of the skull will result in fissures (with or without depression) which are prone to extend towards and involve the base. A certain degree of trauma can be withstood by the vault without apparent injury, the shock being absorbed by the natural elasticity of the bone. If the trauma be a little greater, and the skull bent inward sufficiently, the internal table may give and we then have a fracture of the inner table alone; a condition frequently described in text-books, but rarely seen in practice. A still greater trauma results in dissolution of continuity of the entire thickness of the bone. On the other hand a blow from a sharp cutting instrument may fracture the outer table while the inner table remains intact. The skull may be fractured by "bending" or by "bursting." When violence is applied to the skull in a circumscribed region the immediate site of injury is "bent" inward with resultant local fracture which is said to be "fracture by bending." When the violence is applied over a larger area and more slowly, lines of fracture may be found radiating from the site of impact, often involving the base. The action may be likened to the breaking of a nut in a nut-cracker. This form of fracture is spoken of as "fracture by bursting"; the most striking examples of which are seen in instances in which the head has been caught and crushed between two heavy objects. We often have evidences of both the bending and bursting action in a given case. If the skull were of a uniform thickness throughout, the mechanism would be much easier to determine. As it is we find the peculiarities in the structure of the skull directly influence the directions which fissures take. When fractures of the vault, between the frontal and parietal eminences, involve the base they are frequently accompanied by fissures extending into the middle fossa. When fractures posterior to the parietal eminence are accompanied by basal fissures they usually extend into the posterior fossa and in like manner those anterior to the frontal eminence involve the anterior fossa. In gunshot wounds, especially when produced by the modern high-pressure bullet, the skull sometimes presents what would seem to be an explosive effect similar to that produced by shooting through a barrel filled with water. The nature of the vulnerant body is an extremely important element, for example; the completely jacketed high-velocity rifle ball will usually penetrate cleanly, is not prone to carry in any extraneous materials, and the wound is frequently sterile throughout. On the other hand a blow from a hammer besides driving a portion of the bone into the brain will frequently be found to have carried in hair, dirt, or felt, and the wound is therefore much more liable to infection. Fracture by contrecoup has been the subject of much discussion and although it may be possible for fracture to occur at the opposite pole of the head as a result of the meeting of vibrations, yet its occurrence has been, to say the least, greatly exaggerated. Most of the so-called contrecoup fractures will upon further investigation be found to be fractures by bursting or the result of a second blow on the head. For example: a man sustains a blow on the forehead fracturing the anterior part of the skull, falls heavily to the sidewalk and strikes the back of his head, producing a second fracture in the occipital region; this second fracture is not infrequently considered a fracture by contrecoup when in reality it is but the result of a second blow. The outline and position assumed by depressed fragments will correspond, more or less, to the shape of that portion of the vulnerant body which has produced the fracture. The terms "gutter," "pond," etc., are used to indicate the position of the fragments. When the fragment is depressed and only partially detached from the remainder of the skull, the unbroken bridge of bone connecting the fragment may impart sufficient spring to the depressed portion to pinch and securely hold extraneous materials such as hair and felt. The injuries inflicted by missiles vary with the nature of the projectile, and the weapon from which fired. The lead ball from an ordinary 32 caliber revolver produces considerable damage at the point of entrance, and very commonly remains within the skull, even when fired at close range. A 38 or 44 caliber is much more likely to pass through the skull. The partially jacketed or mushroom bullet usually passes through the head with more or less shattering of bone at the wound of entrance, and extreme damage, comminution and laceration at the wound of exit. The completely jacketed high-velocity projectile, such as used in the army, may penetrate the head with a minimum amount of trauma; the wound of entrance is small and clean cut, the wound of exit is only a trifle larger. Any projectile either low or high in velocity is likely to produce extensive comminution when the skull is struck a glancing blow.

Symptoms of Concussion, Contusion, Laceration and Compression.—The symptoms accompanying fracture of the skull are firstly, those of the fracture itself and secondly, those resulting from injury to the encephalon, which may be either general or localizing. They will depend upon the extent, nature and position of the injury sustained by the brain. Symptoms of fracture are often very meager, and of little importance aside from the concomitant brain injury. Before entering upon the symptoms occurring in connection with fractures of the skull and injuries to the brain, it will be necessary to consider a group of conditions which occurs either with or without fracture, namely,—concussion, contusion, laceration and compression. At least one and sometimes all of these four conditions are associated with fracture of the skull, but the fact that it is possible for them to be present without accompanying injury of the bone renders the diagnosis of fracture of the skull more difficult. Concussion and contusion of the brain are really the same condition, the difference being one of degree.

Concussion consists of a jarring of the brain-substance which results from rapidly putting the head into motion, as by a blow; or by suddenly stopping it while in motion, as in a fall. The symptoms of concussion will vary with the severity of the injury. When slight, the patient is momentarily dazed, develops more or less of a headache and may suffer from vertigo and nausea. When the jarring of the brain-substance is more severe, the patient becomes unconscious, with general muscular relaxation and a cold clammy skin. There may be loss of sphincteric control at the time of the accident, later on the sphincters may fail in reaction, with resultant overdistention of the bladder and bowels. There is general systemic depression, the pulse is weak and thready: the pupils are, as a rule, equal, with a tendency towards dilatation. Reaction to light is present though sluggish. The patient recovers gradually from the unconscious state, requiring some hours, in severe cases, before complete consciousness and good judgment are restored. As the patient recovers he is prone to ask many questions, which are usually concerning his whereabouts, the nature of the accident, etc. The manner in which these questions are put and repeated is most characteristic of the condition. For instance, he may ask where he is; then what happened to him, how it happened; and where some companion may be. These questions are as a rule slowly repeated in the same order, regardless of the fact that they may have been repeatedly answered. It is a peculiar fact that with the loss of memory for the accident and the subsequent unconsciousness, there is also the loss of memory for events immediately preceding the accident. This loss of memory preceding the accident will cover a period proportionate to the severity of the concussion, sometimes many hours, days or even months. As memory returns, this blank space is lessened from both ends until, with complete recovery, the patient is able to remember everything that occurred outside the period of coma. With returning consciousness the patient is often able to state his name before it is possible for him to recollect anything else. It will be some time later before he is capable of answering questions involving numbers, such as his address, date of the month, etc. It is important in this regard to see to it that the patient has fully regained his good judgment as well as his consciousness, since serious consequences may ensue if he be allowed to go about his business unattended. For example, he may be able to state his name, give his occupation, tell what business he was about when injured, etc., and yet if released may be unable to find his way home or may perform some act contrary to good judgment before he has thoroughly regained his mental balance and is himself again. It is therefore wise to keep him under observation for at least a few hours following the accident.

Contusion Contusion as previously stated is but a more severe degree of concussion and accordingly we find the symptoms of concussion present in exaggerated form. Pathologically there is this difference between concussion and contusion: concussion shows no characteristic post-mortem findings, while contusion frequently shows minute punctate hemorrhages throughout the substance of the brain. Like concussion there will be unconsciousness, prostration, disturbances in sphincteric control, cold clammy skin, weak thready pulse, etc. The unconscious period is prolonged and recovery protracted, so that the condition may cover a period of weeks or even longer. Recovery from unconsciousness is slower, and in rare instances the condition may be followed by mania ending in recovery, death or dementia. Protracted and severe headache is not uncommon and vomiting is often persistent. During semiconsciousness, headache is evidenced by the patient putting his hand to his head and later when able to talk he complains of the pain. If the intracranial disturbance is severe enough to be irritative, one or both pupils may show contraction, according to the cerebral regions involved. During recovery, which is gradual, the patient may develop an active delirium and if not restrained may leave his bed and wander about aimlessly. During this semiconscious period he often assumes a perverse, obstinate, mental attitude which renders nursing difficult and sometimes even dangerous. In extreme cases the patient may pass into a typhoid state with sordes, coated tongue, sphincteric disturbances, low muttering delirium, subsultus tendinum, etc. When contusion is severe or prolonged, localizing symptoms are likely to develop; the condition is then recognized as one of laceration or compression as well as contusion. When symptoms of compression develop early they are likely to be due to hemorrhage or laceration, but if they come on late, edema of the brain is probably the cause.

Laceration.—Laceration of the brain tissue without fracture may be considered an intensified, local contusion and is due to the same causes. When it is the direct result of depressed fragments or the entrance into the skull of the vulnerant body we find that the condition may occur more or less independently of the symptoms which usually accompany concussion, contusion and compression. Laceration may accompany contusion and concussion without giving rise to localizing symptoms if the region of the brain involved is not capable of producing peripheral disturbances in function. When the region injured is within some of the so-called silent areas, we have no localizing symptoms. Contusions and lacerations of the brain are a frequent accompaniment of fractures of the base, the most frequent sites being the under surfaces of the frontal lobes and the tips of the spheno-temporal lobes. In depressed fractures of the vault it is common to find the cortex beneath the fragments suffering from laceration. The pulse is usually weak and rapid, resembling concussion in this respect; increased tension and slow pulse are to be expected only when compression develops. The temperature in both concussion and contusion is, as a rule, subnormal but as the conditions merge into the more severe grades of brain injury, such as laceration, the temperature rises above normal.

Compression.—The physical phenomena indicating compression of brain tissue vary widely with the location, rapidity and degree of pressure. The cranial contents are fluid and semifluid, hence the question of intracranial pressure is essentially one of hydrodynamics. The cerebrospinal fluid occupies a considerable space between the brain and the skull, especially at the base, and when hemorrhage occurs within the skull this fluid is displaced into the spinal spaces to make room for the clot within the cranium. Under such conditions the capacity of the skull remains the same and the fluid nature of the contents precludes actual condensation or compression, yet the pressure pervading the entire mass is increased, accounting to some extent for the symptoms. This pressure impedes the circulation within the skull, resulting in intracranial anemia, which is in turn compensated for by the activity of the vasomotor centers which raise the general blood pressure. Hence the slow, high-tension, bounding pulse seen in compression of the encephalon. If the pressure be slowly applied, allowing the cerebrospinal fluid ample time for displacement, a surprisingly large clot may result with but mild symptoms; on the other hand pronounced and rapid symptoms may accompany a small quick hemorrhage. The most pronounced symptoms, therefore, accompany large rapid hemorrhages such as occur from the middle meningeal artery, while the mildest and slowest of onset are seen in cases where a small clot has developed gradually from one of the smaller veins. During compression, the intracranial pressure will be approximately the same throughout the skull but the displacement of cerebral tissue will be greatest surrounding the foreign material, decreasing in all directions within the skull inversely as the square of the distance. The region of greatest displacement will show the greatest amount of cell injury and dissociation between cells, and will therefore be the area to suffer most functionally. If the foreign accumulation takes place rapidly the function of the cortex may be destroyed at once, but if the pressure is exerted more gradually there will be irritation with overaction of the centers, followed by paralysis if the process be carried far enough. Accordingly when motor areas are the seat of displacement we have spasm of groups of muscles according to the cortical regions involved; this overaction or convulsion is followed by paralysis if the pressure is continued and increased. Compression may be the result of hemorrhage from the meningeal or cerebral vessels, from edema following contusion, from depressed fragments of bone and from the forcible introduction of foreign bodies through the skull and into the brain.[1]

Symptoms.—The most common causes of traumatic compression are the depression of fragments and hemorrhage from the meningeal vessels, especially the middle meningeal. The same trauma which causes compression almost invariably produces concussion, and if the concussion does not clear up before the symptoms of compression develop, the patient will present the symptoms of both conditions simultaneously. A return to the unconscious state during recovery from concussion is therefore a symptom characteristic of compression, the conscious or semiconscious interval represents a condition of the patient in which he is coming out of the unconsciousness of concussion before the clot has assumed sufficient size to produce coma from increased intracranial pressure and displacement.

The symptom-complex of fracture of the skull is so variable and the subject so extensive that it is difficult to study the numerous symptoms in detail, and at the same time keep a clear, concise and comprehensive view of the subject as a whole. For this reason we will consider first, in tabulated form, the most frequent symptoms which may accompany the condition, after which they will be taken up in detail. The same difficulties which confront us in the study of these conditions prevail in dealing with the case at the bedside, and unless we have some systematized method of procedure we are more than likely to overlook some of the symptoms.

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[1] **Pathological conditions such as tumors, cysts, etc., are not here considered as they are not related to fractures, except as sequelæ.**

For convenience the symptoms may be divided into local, general and localizing.

Local symptoms.

1. Pain in the region of the fracture.
2. Scalp wounds.
3. Depressions or fissures in the bone.
4. Mobility and crepitus.
5. Escape of blood, cerebrospinal fluid or brain tissue.
6. Ecchymosis.
7. Emphysema.

General symptoms.

8. Unconsciousness.
9. Vomiting.
10. Headache.
11. Vertigo.
12. General flaccidity and loss of deep reflexes.
13. Variations in pulse and blood pressure.
14. Variations in respiration.
15. Variations in temperature.

Localizing symptoms.

16. Deviations in the positions of the eyes.
17. Alterations in pupillary reactions.
18. Local motor and sensory paralyses and disturbances in muscular tone.
19. Disparity in deep reflexes of two sides.
20. Disparity in temperature of two sides.
21. Disturbances in higher psychic function.
22. Aphasias.
23. Cranial nerve symptoms.

It is not to be supposed that any given patient will present all of the above tabulated symptoms, and no one symptom will be present in all cases. Each patient examined will show a different combination of symptoms as a result of the variations in bone and brain injury which occur in different instances. Most fractures of the vault present a more or less complete set of local symptoms, being, as a rule, accompanied by wounds of the scalp. In fractures of the vault localizing symptoms will be present depending upon whether or not the motor areas have been injured. Fractures of the base are less productive of local symptoms, though the general symptoms are usually more pronounced.

LOCAL SYMPTOMS.—1. *Pain in the region of fracture* is present if the patient is conscious; in other words, pain is present if the encephalon is capable of recognizing the afferent impulses which constitute pain. In many cases of semiconsciousness pain is indicated by groaning or by repeatedly carrying the hand to the seat of the injury. Pain is present in simple scalp wounds but is not as severe as that which results when the skull is fractured and the meninges injured.

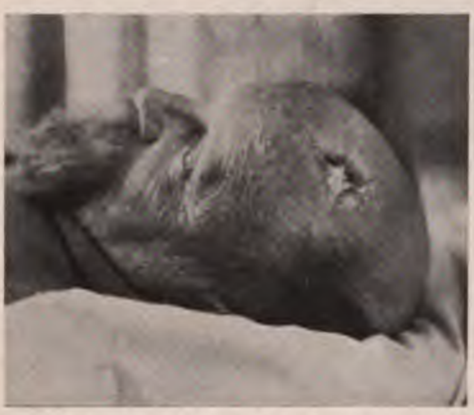

Fig. 521.—Depressed fracture of the vault produced by a fragment of an exploding shell during the Franco-Prussian war. History of severe infection. No untoward late results.

2. The *symptoms of scalp wounds* do not necessarily accompany those of fracture of the skull, but the frequent association of the two conditions in fracture of the vault would render the picture misleading if the symptoms of scalp injury were not included under the local symptoms of fracture of the skull (see "Scalp Wounds," page 382).

3. *Depressions of bone* may sometimes be recognized by inspection alone, though the symptom is usually found only by palpation and exploration of the scalp wound. Fissures may be present radiating from a depression or existing independently, and can be recognized only by examination of the bone.

4. *Mobility and crepitus* may be present in rare instances but are, as a rule, only elicited during exploration of the bones of the

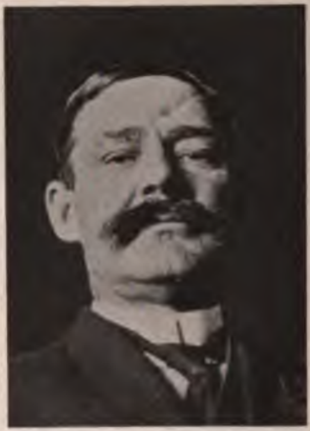

Fig. 522.—Old depressed fracture in frontal region. Injury sustained during childhood. No symptoms whatever of intracranial disturbance.

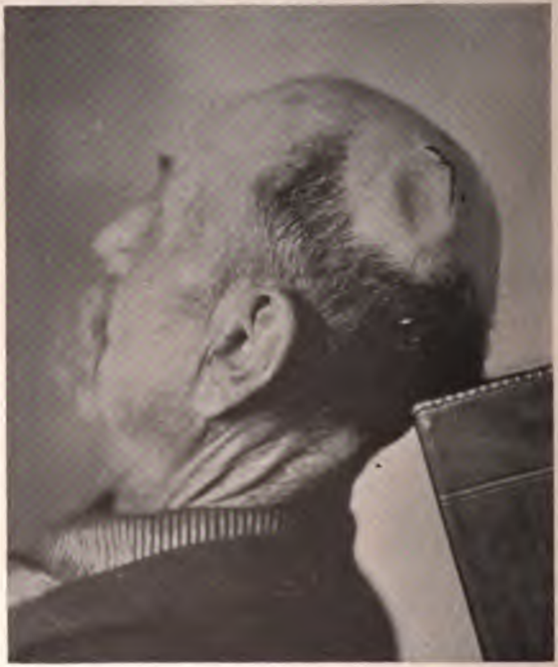

Fig. 523.—Depressed fracture of skull in left parietal region of about eighteen years' standing. Not followed by any late symptoms. Patient presents himself at this time for treatment of slight scalp wound seen at the upper margin of the old depression.

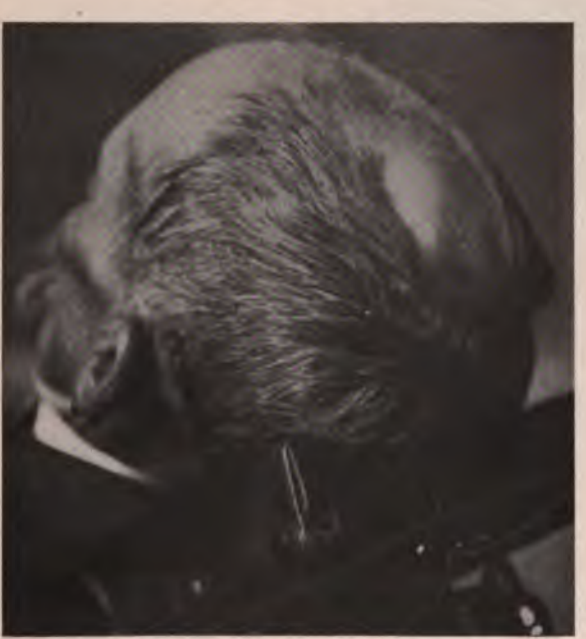

Fig. 524.—Depressed fracture of the vault without symptoms for over twenty years. Of late the patient complains of pain at the seat of fracture followed at times by general headache, vertigo and dizziness. An example of the development of late symptoms in instances in which depression is allowed to go uncorrected.

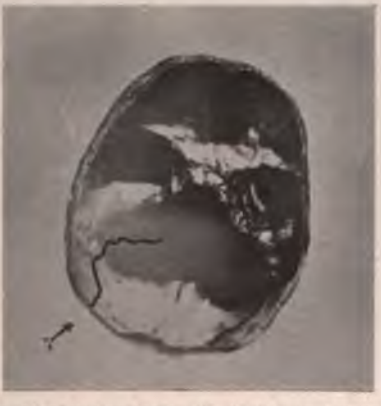

Fig. 525.—Fracture of posterior fossa due to fall on the back of head. No symptoms suggestive of the condition until the day following the injury (nearly twenty-four hours). Patient went about his business stating that he was perfectly well and did not desire any attention. Death due to intracranial pressure produced by hemorrhage from a small vein in the posterior fossa which was torn as it crossed the line of fracture. Hemorrhage ultimately covered the base of the brain. Patient found dead in bed next morning. Moderate quantity of venous blood had made its escape from the nasal cavities during sleep. Line of fracture retouched as the photograph was poor, having been taken by the light of a 16 c.p. electric lamp.

vault. A fracture may encircle the skull, dividing it into two portions, and with such a condition it may be possible to move one part of the skull on the other, thus producing mobility and sometimes crepitus.

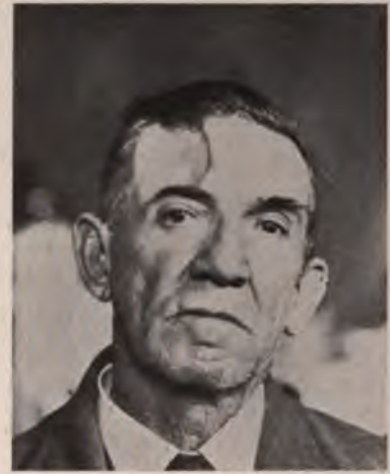

Fig. 526.—Old depressed fracture of the frontal region. Case operated and bone removed. Uneventful recovery.

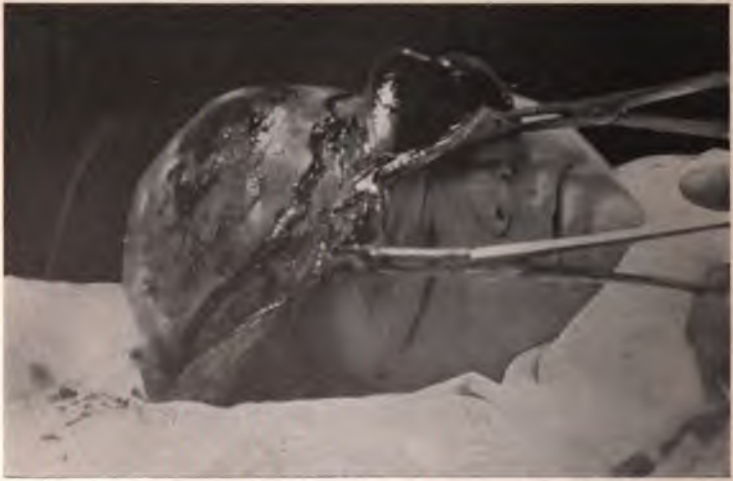

Fig. 527.—Fracture running from base to vault and nearly encircling the skull. Patient lived a few hours following the injury. Photograph taken shortly after death. Lesion result of fall from window.

5. Fracture through the base of the skull may allow the *escape of blood or cerebrospinal fluid* and rarely *brain tissue* from the ears, nose, or mouth according to the region of fracture. In fracture of the vault these same materials may escape directly through the scalp wound or into the tissues of the scalp when the condi-

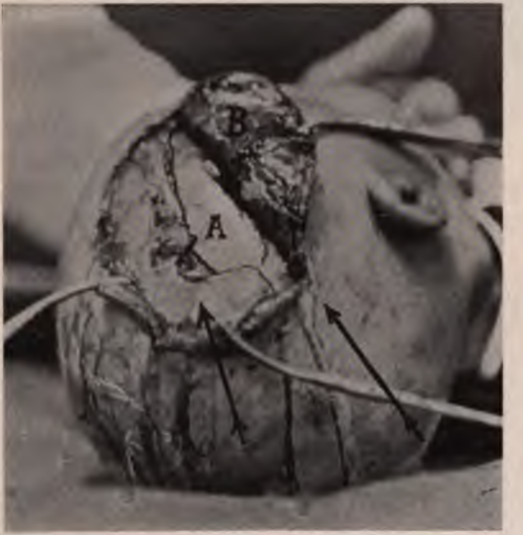

Fig. 528.—Severe comminuted depressed fracture of the vault, during operation. *A*. represents a large depressed fragment of bone. *B*. represents the horseshoe-shaped flap turned back to expose the fracture. The arrow to the left is in line with fracture above the large fragment. The arrow to the right is in line with the fracture below the fragment. The upper portion of the fragment is considerably depressed.

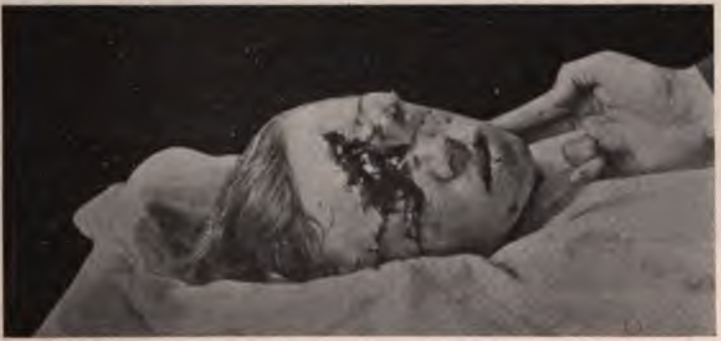

Fig. 529.—Example of the explosive effect of the modern high pressure missile at close range. Wound inflicted with a 32-20 cartridge fired from a Smith & Wesson revolver. (Soft nose bullet.) Picture taken about twenty minutes after injury. Patient lived about one hour.

tion is not compound. It should be remembered that a large proportion of basal fractures result from the extension of a linear fracture of the vault into the base, and hence are fractures of both vault and base. The escape of brain tissue is much more common in fracture of the vault than it is when the base alone is involved. Hemorrhage is extremely variable in quantity and duration. It may be very severe for a few minutes or blood may continue to flow in small amounts for a period of days. The flow of cerebrospinal fluid is likely to persist for at least some hours, usually days, when leakage is once established. It is commonly mixed with blood during the first few hours or the first day, after which it is likely to become clear and free from accompanying hemorrhage.

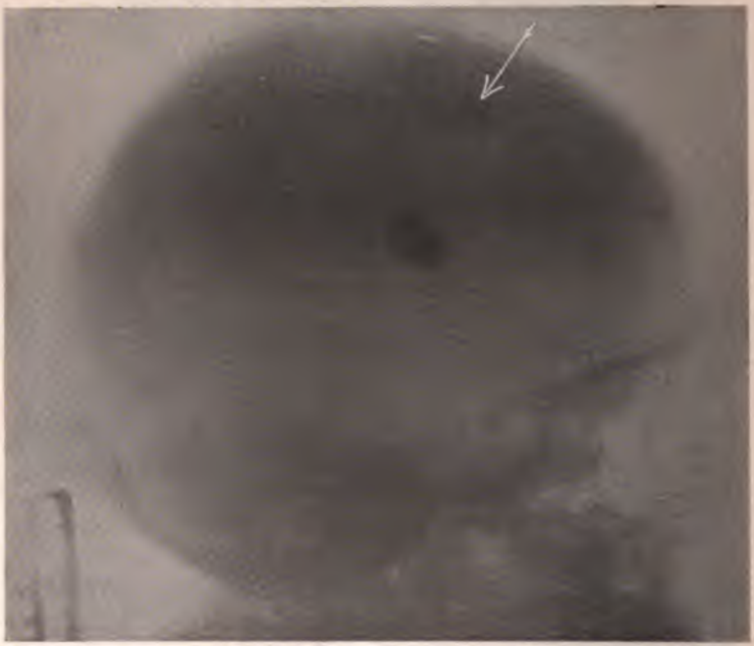

Fig. 530.—Bullet in head. The arrow points to the opening in the skull through which the bullet entered.

6. *Ecchymosis* beneath the conjunctiva is a common symptom in fracture of the anterior fossa and may be accompanied by exophthalmos if the collection of blood within the orbit is of any considerable quantity. Ecchymosis beneath the eyelids may arise

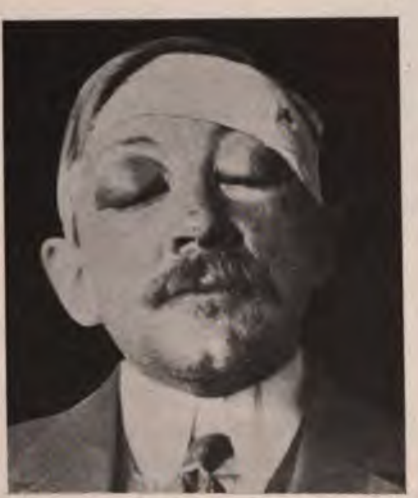

Fig. 531.—Pronounced swelling and ecchymosis of both eyes following small scalp wound on left side of forehead. Condition suggestive of fracture of the base of the skull since there has been no trauma near the patient's right eye to account for its swelling and blackening.

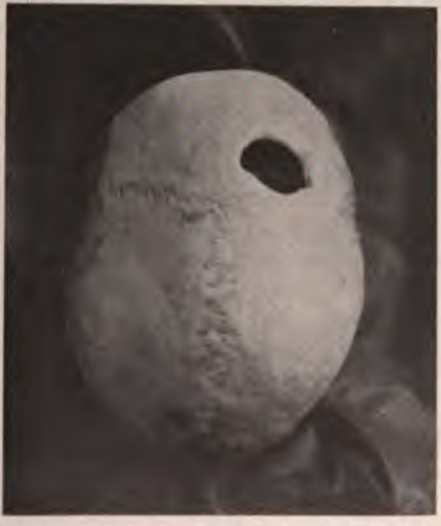

Fig. 532.—Case of severe depressed fracture of the vault. The patient went about for ten days without any attention to the condition. He then presented himself for medical treatment because of a headache. Parts badly infected. Operation performed with elevation of the depressed fragments. Recovery. Two years later he committed suicide and the calvarium was obtained at autopsy. Patient was a hard drinker and was drunk at the time of the injury, which accounts for his ten days' neglect of the fracture.

from the same causes; it usually spreads outward from the internal canthus and is accompanied by subconjunctival ecchymosis. Exophthalmos with pronounced swelling and ecchymosis of the lids is commonly seen in suicidal gunshot injuries in which the revolver has been held to the temple, the ball having passed through the skull directly behind the orbits or through their apices. Ecchymosis about the mastoids and nape of the neck is not uncommonly seen in fracture of the posterior fossa though it rarely develops before the first twelve or twenty-four hours. Battle's sign consists of ecchymosis following the course of the posterior auricular artery and is sometimes seen in fracture of the posterior fossa.

7. *Emphysema* behind the ear or in the region of the glabella sometimes occurs when the fracture opens the mastoid cells or frontal sinuses. Under such conditions air is much more likely to remain in the tissues if there is no accompanying scalp wound to allow its escape.

GENERAL SYMPTOMS.—The general symptoms accompanying fracture of the skull are much the same as seen in concussion, contusion, laceration and compression previously described.

8. *Unconsciousness* is a common state in head injury and usually obliterates symptoms which might otherwise be of value in diagnosis and treatment. Although unconsciousness accompanies most head injuries and is more or less proportionate to the severity of the case, yet in exceptional instances it may be of the mildest type, or absent, even though the condition be grave. Fractures of the base are much more uniformly accompanied by unconsciousness than are fractures of the vault. The degree of unconsciousness is extremely variable, ranging from cases of momentary insensibility to cases in which the coma is profound. Roughly speaking the severe cases are accompanied by the more profound grades of unconsciousness. The symptom has already been described under the heading of concussion, contusion, laceration and compression (page 407).

9. *Vomiting* is a symptom which is commonly present in the early stages of fracture of the skull though it is not in any way pathognomonic, since it regularly occurs in concussion and allied conditions when fracture is absent. Vomiting occurs in so many conditions that it is of little significance. It is seldom present after the first few hours though in severe cases it may persist for

a considerable period. In rare instances the vomiting may be projectile in character and unassociated with nausea. As a late symptom it may occur with cerebral tumor or abscess.

10. *Headache* is a common symptom following head injuries of all kinds. A slight blow on the head without disturbances in consciousness, or any other symptom, may be followed by headache for a day or so. On the other hand, headache may be the most pronounced symptom of a serious brain lesion. Headache as a late symptom of fracture of the skull is discussed on page 451.

11. *Vertigo* is often present though its recognition is frequently prevented by other symptoms such as unconsciousness, prostration, etc. When persistent it is most often associated with injuries of the cerebellum or disturbances in the end organs or nerve tracts leading to the cerebellum. One of the important functions of this portion of the brain is equilibration which requires an uninterrupted and complete flow of afferent impulses, especially from the cochlea, semicircular canals, eye and muscles of the body. When the end organs are suddenly thrown out of function or the tracts leading from them are interfered with the cerebellum fails to receive the necessary data for the performance of its peculiar function and the symptoms of vertigo result. Vertigo may follow excessive impulses from a given region, as well as absence or diminution of impulses. Thus, irritative lesions of the semicircular canals may flood the cerebellum, so to speak, with abnormally strong or incorrect impulses so that the function of this portion of the brain is disturbed. The conditions in which such disturbance may occur are legion; it may be present in mild or severe cases, either organic or functional in nature, and hence vertigo is a common symptom and is usually of little diagnostic value. It rarely persists however if there is no organic lesion present. It may be subjective or objective; the patient feels that he is turning, or suffers from the sensation of surrounding objects revolving about him.

12. *General flaccidity* sometimes including sphincteric relaxation is a condition common to all forms of profound coma and will therefore be seen in the more severe types of head injury. The more sudden and violent the onset of coma the greater the probability of involuntary evacuations.

The deep reflexes may be lost in coma from any cause if the unconsciousness is extremely profound. They are absent, therefore, in head injuries of the more severe type. (See page 423 for deep reflexes as a localizing symptom.)

13. *Variations in the pulse and blood pressure* occur as already described under concussion and allied conditions (see page 407). When shock alone is present the pulse will be rapid and the tension low; when cerebral compression occurs the pressure rises and the pulse becomes slow and bounding. A patient in extremis will show a weak, rapid, irregular pulse regardless of the presence of compression.

14. *Variations in respiration* are common in head injuries. Any profound unconsciousness may be accompanied by stertorous breathing especially if the person occupies the dorsal recumbent position. It is common in deep sleep and is due to relaxation of the soft palate and lips. It may be sighing, languid, explosive, irregular, shallow, deep, etc. Rhythmic disturbances are sometimes seen, as exemplified in Cheyne-Stokes' respiration in which the pectoral excursion increases with each respiration until the patient presents the symptoms of pronounced dyspnœa, when the respiratory excursions grow progressively weaker until a condition of apnœa is again reached;—after a short period of quiescence the cycle is repeated. In some instances irritation of the respiratory center produces a pronounced snorting with each inspiration. The more severe cases of head injury are often accompanied by the more pronounced disturbances in respiration.

15. *Variations in temperature* occur commonly in head injuries. Simple concussion is accompanied by lowering of temperature in most cases. Laceration of the brain tissue, contusion and compression are attended by rise in temperature if the condition is at all severe. Variations in temperature are considered among the general symptoms, yet an extreme elevation of temperature (106°–109° F.) accompanies pontine lesions and hence the temperature becomes a localizing symptom.

LOCALIZING SYMPTOMS.—The localizing symptoms occurring in head injuries are extremely variable, moreover unconsciousness obscures many of these symptoms early in the condition.

16. *Deviations in the positions of the eyes* are common and show considerable variation. The eye of the injured side may be turned in any direction regardless of the position of the opposite eye. External and internal strabismus or an upward turning of the eye are common. Turning of the head and both eyes toward

the side of the lesion is not infrequently found and is known as "conjugate deviation." Nystagmus is sometimes observed.

17. *Alterations in pupillary reactions* and size usually accompany fracture of the base of the skull. The most common disturbance is that of dilatation of the pupil with loss or diminution in reaction on the same side as the lesion. The pupil of the opposite side is often normal in size and reaction. Pronounced contraction usually means an irritative lesion of the third nerve but is rarely seen. Loss of reaction in one or both pupils is a grave symptom. When the optic nerve or tract anterior to the oculo-motor nuclei is torn the pupillary reflex is abolished through destruction of the afferent arc of the reflex arc. Wernicke's hemianoptic pupillary reaction may be present in cortical visual lesions.[1]

18. *Local paralyses and disturbances in muscular tone* may be present if the cortex has been injured, monoplegias, hemiplegias or crossed paralyses may be present according to the site of the lesion. The paralysis may be overlooked in the unconscious state if the surgeon is not observant. If the cortical lesion is irritative the corresponding peripheral area will show increased muscular tone, twitching or spasm. When the pressure becomes sufficient to throw the involved area of the cortex out of function paralysis develops. Sensory losses frequently occur over areas corresponding in extent with the motor paralysis, the anesthesia usually preceding the paretic condition.

19. *Disparity in deep reflexes.*—When paralysis exists in an extremity following cortical injuries the deep reflexes are diminished or lost throughout the paralyzed area. If the cortical lesion is irritative as indicated by increased muscular tone, twitchings or spasm, the deep reflexes in the member presided over (i. e., the con-

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[1] The author has observed an irregularity in the rotundity of the pupil in about a dozen instances of fracture of the posterior fossa with cerebellar injury, though he cannot state definitely at the present time that this pupillary peculiarity is necessarily indicative of cerebellar disturbances. Dilatation of the upper outer quadrant of the iris has been present in most instances (in one case this same portion of the iris showed more contraction than the remaining three quarters of the pupillary circumference). The same irregularity, though much less pronounced, occurs at times in alcoholism, and the oval pupil is reported as one of the symptoms of Gerlier's disease. Alcohol has a distinct influence on the cerebellum as is indicated by the ataxic condition of drunkenness and the symptoms of Gerlier's disease all point unmistakably to cerebellar disturbances. The nerve supply to the dilating fibres of the upper outer quadrant of the iris are from a different portion of the sympathetic than those innervating the remainder of the pupil; the clinical observations therefore are, to some extent, in accordance with the anatomical facts. Further observation and experiment will determine the value of the symptom.

tralateral half of face, arm or leg) will be exaggerated. Thus an arm or leg with an irritative cortical lesion in the opposite hemisphere of the cerebrum will show an increase of the deep reflexes when compared with the sound limb. If the cortical lesion be paralytic the deep reflexes will be less than those of the opposite unaffected member, or what is still more common they will be entirely wanting early in the condition.

20. *The temperature of the paralyzed limb* will usually show a reduction of one or one and a half degrees below that of the opposite member. Twenty-four to forty-eight hours following the injury the temperature in the affected member is likely to rise a degree or so above normal, being higher than the temperature observed in the opposite extremity. These surface temperatures are best taken by the surgeon himself, to secure the most accurate results.[1]

21. *Disturbance in the higher psychic function* (judgment, reasoning, concentration, etc.) is sometimes attendant upon lesions of the frontal lobes. The disturbances in function however are by no means constantly proportionate to the extent and severity of the injury. Severe damage may occur in the frontal region with loss of brain tissue and still not be followed by any appreciable disturbance in the reasoning powers of the individual, yet injury in this region is at times attended by distinct clouding of the intellect or disturbed mentality. Damage to the frontal lobes is much more likely to be followed by functional impairment in children than in adults and is probably due to the fact that the injury is sustained during the developmental period.

22. *Aphasias* will seldom be noted early following fracture of the skull because of unconsciousness. Later on the patient may show auditory aphasia, visual aphasia, motor aphasia or graphic motor aphasia or any combination of these defects. Auditory and visual aphasia most frequently occur together. The center for auditory word memories is in the left temporal lobe, that for visual word memories is in the left angular gyrus, that for motor memories is in the foot of the third left frontal convolution, and the remaining center for graphic motor memories is probably located in the second left frontal convolution near the centers for the right

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[1] In taking surface temperature the skin should be thoroughly dried with a pledget of cotton and the thermometer held in place with an adhesive strap for five minutes actual count by the watch. Alcohol should not be used in cleaning and drying the skin because of the refrigerant action attendant upon evaporation.

hand. In left-handed persons these speech centers are located on the opposite side. Any of these various types of aphasias may be present according to the site of the cortical lesion or the damage done to the tracts leading to or from them. Inasmuch as these different functions are all more or less interdependent we will see the different types of aphasias occurring together in varying degrees and combinations. The stereognostic sense is located in the parietal lobe and injury to this region will be followed by astereognosis.

23. Organic lesions and functional disturbances in the *cranial nerves* commonly accompany fracture of the skull, especially the base, and the symptoms will vary with the function of the nerve. Many of the cranial nerve functions are sensory and therefore subjective in nature so that the symptoms of disturbed or destroyed function are not recognizable during unconsciousness. Any of the cranial nerves may be injured in fracture of the base or their centers may be irritated or destroyed in lesions involving the bulb. The function of these nerves may be disturbed by shock or by intracranial pressure without organic lesion in either center or nerve so that restoration of function is complete when the intracranial pressure is removed or concussion passes off. Complete loss of function usually means permanent impairment; slight loss of function is often followed by complete recovery. Loss of function in some of the cranial nerves may come on some time following the accident especially if meningitis develops. It is seldom that a single cranial nerve is injured.

I. *Consciousness* is necessary to determine the presence or absence of smell, hence disturbances in this sense cannot be recognized early. Fracture of the anterior fossa, hemorrhage between the olfactory bulb and the cribriform plate, raising and tearing the bulb from the olfactory nerves, hemorrhage within the bulb or above it with pressure, or thrust wounds through the nose may injure or destroy this sense.

II. The *optic nerve* is sometimes injured in fractures of the base. The cella Turcica seems to be frequently involved in fractures traversing the base and the close proximity of the optic nerves, chiasm and tracts accounts for blindness and some forms of impaired vision which may follow basal fracture. Injury as the nerve passes through the optic foramen is probably most common. Blindness may be noted as soon as the patient regains consciousness and is due to hemorrhage within or about the nerve or laceration of the nerve itself. Blindness coming on some time after the injury has been noted in some cases of fracture of the base and may be due to pressure from callus formation when the fracture passes through the optic foramen. (See "Alterations in Pupillary Reactions," page 423.)

III, IV, and VI. *The third, fourth and sixth cranial nerves* have long intracranial courses beneath the brain and are therefore especially exposed to injury in fractures of the base. The third nerve is more commonly injured in one of its branches than is the entire nerve. Paralysis of all the branches of the motor oculi is followed by external strabismus and dilatation of the pupil. The eyeball assumes different positions when different branches of the third are involved. Paralysis of the sixth is followed by internal strabismus. Paralysis of the fourth nerve is more difficult to recognize; it may be accompanied by diplopia or looking downward.

V. The *fifth nerve* is the sensory nerve of the face, and innervates the muscles of mastication. Anesthesia of the face follows injury of this nerve and if the damage is permanent, herpes, keratitis neuroparalytica and trophic disturbances may follow in the skin of the face. The motor fibres supplying the muscles of mastication travel with the third or inferior maxillary division.

VII. The *seventh* supplies all the muscles of the face and the buccinator. Injury to this nerve is attended by the characteristic symptoms of Bell's palsy. It is the most frequently injured of the twelve cranial nerves.

VIII. The *eighth cranial nerve* is the nerve of hearing and when torn across will be followed by deafness. Fracture through the petrous portion of the temporal may injure the organs of hearing or clots may collect within the tympanum and thus disturb hearing without injury to the nerve itself. The bone conduction test should be the only one, therefore, on which to base a diagnosis of injury to the nerve. Irritation of the eighth nerve is likely to be accompanied by persistent tinnitus and aural vertigo as well as impaired hearing.

IX, X, and XI. The *ninth, tenth and eleventh cranial nerves* have a short intracranial course and in their exit from the skull occupy the middle portion of the jugular foramen with the lateral sinus on one side and the inferior petrosal sinus on the other.

The large size of the foramen through which they pass and their short intracranial courses render them less liable to injury than most other nerves passing through the base of the skull. Their nuclei, however, situated in the medulla are very commonly temporarily disturbed in function by increased intracranial pressure or raised blood tension, as evidenced by the respiratory, cardiac and gastric disturbances occurring in head injuries. A traumatic lesion which seriously injures or destroys these centers is usually immediately fatal. Injuries of the *ninth nerve,* as evidenced by disturbances in swallowing, rarely occur in head injuries. Sensory and motor disturbances in the larynx, disturbances of the stomach and intestines, disturbance in heart action and respiration, may accompany injury to or disturbed function of the vagus.

The *spinal-accessory* supplies the sterno-mastoid and upper portion of the trapezius on the same side and paralysis of these two muscles follows injury to the eleventh cranial nerve.

XII. The *twelfth cranial nerve* is rarely injured in fracture of the skull. Paralysis of half the tongue followed by trophic changes in the paretic side of the organ and disturbances in the innervation of certain muscles of the neck are the symptoms.

Diagnosis.—The diagnosis of fracture of the skull may be so evident that one cannot fail to recognize the condition, but on the other hand the symptoms may, in some cases, be so obscured or indefinite that it is impossible to state whether or not fracture exists.

A searching history and thorough examination are the two essentials for proper diagnosis.

The *history* should be taken in systematic order, inquiry with proper deductions being made on the following points: nature of accident, manner in which injury was sustained with estimation of degree of trauma, onset and degree of unconsciousness if present, symptoms displayed prior to observation by the surgeon. Was there spasm? Was there hemorrhage from mouth, nose or ears? If blood is found in the external auditory canal, did it run into ear from an adjoining wound of face or scalp, or did it first appear in the ear? What were the patient's surroundings? Was there probability of poison having been given to, or taken by him? Did previous disease exist, such as nephritis or diabetes? Has he been subject to fits of any kind? What has been the previous state of his health? Has he or any of his family been subject to nervous diseases or conditions in which unconsciousness took place? What is his age?

Examination.—If patient is unconscious determine as far as possible the depth of coma, examine pupils, note reaction to light, compare size of two pupils, and circularity of each. Note the position of eyes, and position of head with relation to position of eyes, note motility of eyeballs, examine for paralyses or spasm of extremities or face. Compare deep reflexes of two sides, test for Babinski's sign, patella clonus, ankle clonus. Observe general muscular tone and condition of skin, variations in pulse and blood pressure, abnormalities in respiration. Compare temperature of two sides. Examine scalp carefully for evidences of trauma; if wounds of the scalp or hematomata are present they should be explored and enlarged if necessary, with due precaution for asepsis. The scalp should be shaved and the wound treated as described previously under the heading of scalp wounds. Cranial sutures should not be mistaken for linear fractures while inspecting the bottom of the wound, and rents in the pericranium should not be confused with depression, when palpation is employed. Use probe rarely, with caution and only after sterilization in flame. Determine mobility and crepitus when present. Note nature and amount of fluids escaping from one or both ears. Pure blood or blood mixed with serum, liquor Cotunii, or cerebrospinal fluid may escape from the ear, nose, or mouth. It would seem an easy matter to recognize cerebrospinal fluid when mixed with blood, but the condition seems to have been simulated by large quantities of serum or liquor Cotunii, and it is often a difficult matter to state definitely that a given fluid escaping from the skull contains cerebrospinal fluid. When, however, the fluid is watery, low in albumin and high in sodium chlorid one may feel reasonably sure that cerebrospinal fluid is present. The face and scalp should be examined for ecchymosis and emphysema. Ecchymosis about the eye with adjoining bruise or abrasion of the face is indicative only of superficial injury. Ecchymosis about the eye spreading toward the external canthus from the inner angle and accompanied by conjunctival ecchymosis and no proximate trauma of the face is indicative of fracture of the base, the blood coming from within the orbit

A chart should be kept and the symptoms entered in the order of their appearance. Special note should be made of the temperature, respiration, pulse, blood pressure and depth of unconsciousness. Early unconsciousness is usually the result of concussion, prolonged unconsciousness is suggestive of contusion, laceration or compression. A return to the unconscious state is almost always due to intracranial hemorrhage. Rise of blood pressure with slow pulse usually indicates hemorrhage. Palpation alone is too inaccurate to be dependable in determining the blood pressure; we should use the sphygmomanometer. Before drawing conclusions on the blood pressure we should know the condition of the arteries and the age of the patient, at least approximately. For example: a tension of 170 m.m. in a man of sixty with arteriosclerosis would not be as indicative of hemorrhage as the same pressure in a man of twenty-five with normal elastic arteries.

Albumin and sugar may make their appearance in the urine a short time following head injuries and for this reason the patient should be catheterized at the earliest possible moment and the urine analyzed to determine the condition of the urine excreted prior to the accident. This urinalysis when compared with later tests may indicate the source of sugar or albumin when present. The value of localizing symptoms in diagnosis will best be appreciated by reviewing these symptoms on page 412.

A careful consideration of the facts disclosed in the history and determined by examination will in most cases afford sufficient data for a correct diagnosis. Many of the symptoms of fracture which are of value are subjective in nature or appear late in the course of the case and are not available at the usual time of the first examination.

Differential Diagnosis.—Fracture of the skull with brain injury is usually associated with a more or less complete loss of consciousness and it will be necessary in avoiding mistakes to exclude other forms of coma. A mistaken diagnosis may deprive the patient of a much needed decompressive operation or may subject him to dangerous surgical procedure when the coma is due to toxic or other conditions not amenable to surgery. It will therefore be necessary to consider other forms of unconsciousness that we may systematically exclude them before making a diagnosis of brain injury. The following classification, like most classifications, is by no means ideal, yet it will form a working basis on which to consider the causes of coma.

A. Coma due to temporary circulatory disturbance.
  1. Syncope.
  2. Shock.
  3. Cerebral congestion.
  4. Cerebral anemia.

B. Coma due to medicinal and other extraneous poisons circulating in the blood.
  5. Alcoholic coma.
  6. Opium coma.
  7. Phenol coma.
  8. Chloral coma.
  9. Asphyxia from illuminating gas.
  10. Asphyxia from carbon monoxid.
  11. Ptomaine coma.
  12. Lead coma.
  13. Belladonna and its alkaloids.
  14. Hyocyamus and its alkaloids.

C. Coma following chronic disease and due to toxins arising within the body.
  15. Uremic coma.
  16. Diabetic coma.

D. Reflex comas and those preceding or following acute infections.
  17. Convulsions and coma sometimes precede the acute exanthemata in childhood.
  18. Reflex convulsions and coma may accompany dentitional and gastro-intestinal disturbances in children.
  19. Comatose conditions may accompany acute infections such as typhoid, pneumonia, etc.

E. Diseases and neuroses of the central nervous system are not infrequently accompanied by coma.
  20. Hysteria and feigning.
  21. Epilepsy.
  22. Apoplexy.
    Cerebral hemorrhage.
    Cerebral embolism.
    Cerebral thrombosis.

23. Cerebral syphilis.
24. Cerebral meningitis.
25. Abscess of brain.
26. Tumor of brain.
27. Epileptiform and apoplectiform attacks due to cerebral arterial disease.

A. COMA DUE TO TEMPORARY CIRCULATORY DISTURBANCE.—1. *Syncope.*—The essential of syncope is the fact that it is transient; lowering of the head or shock, such as is produced by cold water, is accompanied by the return of consciousness within a few minutes. Pallor of the skin and mucous membranes, with cold, clammy, relaxed skin are constant; pupils are equal and dilated, with reaction to light sluggish or absent; pulse weak, rapid and sometimes perceptible only in the larger vessels; temperature subnormal; respiration weak, shallow and quiet. The characteristic symptoms of other forms of coma are absent. In simple syncope, not due to organic heart disease, the attack is evanescent. Disease of the heart or vessels may produce an unconsciousness more profound and prolonged in character, with a tendency toward cyanosis. Hysterical syncope is likely to be repeated; it lacks the essential symptoms of simple syncope. The color of the skin and mucous membranes and the pulse are unchanged, unless the attack is accompanied by severe muscular exertion, as seen in hysterical convulsions.

2. *Shock.*—Shock and cerebral concussion are so closely associated that, for practical purposes, it is useless to distinguish closely between them. Shock is a condition accompanying cerebral concussion though it may occur independently of it, as seen following hemorrhage. In the milder forms of shock consciousness may be practically undisturbed, while in severer forms coma is often profound. Pulse is weak, rapid, often irregular and sometimes slow; respiration shallow, frequent and usually quiet; the functional activities of the entire body are lessened; the temperature falls below normal early in the condition and the blood pressure may be markedly reduced. The symptoms usually last for a few hours; recovery is the rule except in the severer forms. Vomiting frequently occurs as the patient is regaining consciousness. Interruption in recovery, prolonged or delayed shock or an increase in the symptoms after the first few hours usually indicates

serious complications. In simple shock or concussion localizing symptoms are absent.

3. *Cerebral congestion.*—The most common cause of congestion of the brain is isolation. The onset of coma is usually gradual and preceded by headache and delirium. The arterial tension is high: pulse rapid, full and strong: respiration often rapid, deep and noisy: temperature usually a degree or two above normal. The history of exposure to a torrid sun, absence of trauma, and local and localizing symptoms differentiate the condition from brain injury.

4. *Cerebral anemia.*—Aside from syncope and shock anemia of the brain is commonly the result of exsanguination. The diagnosis is made on the history of loss of blood and the symptoms, which resemble shock. Any degree of loss of consciousness may be present from slight lethargy to deep coma. Delirium and convulsions may occur when the hemorrhage has been sudden and profuse.

B. Coma Due to Medicinal and Other Extraneous Poisons Circulating in the Blood.—Unconsciousness resulting from acute poisoning has always been a source of difficulty in diagnosing unconscious states due to head injury. Simple drunkenness is probably the most common cause of abnormal unconsciousness and the frequency with which this condition is seen, together with the predisposition these cases show to accidental injury, makes the subject an important one. Persons attempting suicide not infrequently take more than one poison to accomplish the result or may combine poison with self-inflicted injury, such as cutting the throat or jumping from a window. The diagnosis under such conditions is rendered more difficult and accordingly the surgeon should not be satisfied as soon as a single cause of unconsciousness is found. Of one hundred consecutive poison cases treated by the author thirty-four were due to opium or morphine, twenty to phenol, nine to alcohol, seven to ptomaine, six to chloroform, four to strychnine, four to chloral, three to bichlorid of mercury, two to illuminating gas, three were complicated by hysteria, in four the nature of the poison was unknown and in nineteen cases the poison was unusual and has been classified under the heading "miscellaneous." Deep coma was present in thirty-six of the hundred cases, death resulted almost immediately in five cases and in thirteen instances the cause of poisoning or coma was multiple. Simple cases of alcoholism were not included among these cases except as a complication of some other poison or unless the case presented serious symptoms. Simple cases of hysteria are also excluded except as a complication of poison. In the majority of these cases, by close examination of the patient's surroundings or by inquiry from those present, it was possible to determine the nature of the poison ingested, independently of the symptoms presented by the case. These figures indicate to some extent the difficulty sometimes experienced in determining the cause of unconsciousness and illustrate the necessity of being familiar with the symptoms occurring in the various forms of poisoning. In this respect we have to consider not only the most frequent forms of poisoning but those most frequently producing a comatose condition which might be mistaken for the unconsciousness following head injury.

5. *Alcoholic coma.*—The condition is so common that the symptoms are usually recognized without difficulty as being due to alcohol. The symptoms however are so similar to the general symptoms occurring in head injury that it is sometimes only by the most careful and persistent observation that the existence of the two conditions may be recognized when they occur together. There are two types of alcoholic coma which deserve mention; the first is the acute type occurring in persons not habitually accustomed to the use of alcohol and the second is that of acute drunkenness in a chronic drunkard. In the first we have simply the acute effects of the drug, taken in over-dose, while in the second we have the acute effects of the drug added to the condition of chronic alcoholism. The generally unkempt condition, bloated face, chronically inflamed eyes, reddened nose, putty-like complexion with edema beneath the lower eyelids (usually indicating chronic nephritis) all point to chronic alcoholism. This appearance gives the examiner a portion of the history of the case at a glance. The depth of coma varies in acute alcoholism according to the amount of alcohol ingested. It is usually possible to rouse the patient by suddenly producing pain such as may be inflicted by supraorbital pressure, by pressure behind the ramus of the jaw, by pressing a lead pencil into the web of the fingers or by means of the electric brush. When aroused he is usually noisy and abusive until the annoyance is removed, when he lapses back into his drunken sleep or stupor. If he can be made to talk, even if only a little, the characteristic thick speech of alcoholism is recognized. Sometimes the coma is extremely profound so that it is not possible to

rouse him by any ordinary means and we are obliged to resort to the electric brush. Repeated stimuli will often produce results when a single application of the brush or of supraorbital pressure would elicit no response. Alcohol may be detected on the patient's breath. The clean fresh breath of simple acute alcoholism is quite different from the characteristically foul and offensive odor emanating from the mouth of a chronic drunkard. The pupils are usually equal, slightly dilated and respond sluggishly to light, though they may be either moderately contracted or dilated. The temperature is usually normal, unless he has been exposed to weather as frequently occurs in drunkenness. The pulse is as a rule increased slightly in rate and low in volume. Slight cyanosis commonly occurs about the face and neck. The respiration is often blowing or stertorous. The skin is relaxed and covered with cold sweat. The deep reflexes are present though reduced. The appearance of the patient, alcoholic breath, condition of the pupils, respiration, temperature, pulse and nature of the coma together with the absence of local and localizing symptoms will usually serve to differentiate alcoholic coma from brain injury. Another frequent form of unconsciousness (to be taken up later on page 443) is that of apoplectiform and epileptiform convulsions (commonly spoken of as "whiskey fits"), which occur in advanced cases of chronic alcoholism.

6. *Opium coma.*—Opium or its alkaloids is one of the common methods of suicide, and the length of time between ingestion and coma is ample, even when large doses are taken, to permit the patient already bent on self-destruction to meet with accident. The condition due to opium poisoning is characteristic; the pulse is slow, usually weak; respiration extremely slow (5 or 6 to the minute), usually noisy from the relaxed condition of the soft palate and lips; temperature generally normal, though it may be slightly subnormal and may rise preceding dissolution. Pupils are strongly contracted and usually show little or no tendency to react to light. Inquiry into the surroundings of the case will generally disclose the cause of the coma in the form of an empty labeled vial or box. The history of the case, the characteristic symptom-complex, the absence of local and localizing symptoms will readily differentiate the condition from brain injury.

7. *Phenol coma.*—Poisoning from carbolic acid, especially large

doses, produces unconsciousness within a short time of ingestion. The skin is pale, cold, clammy and relaxed; respiration stertorous; pulse weak and rapid; temperature may be subnormal; pupils usually equal, dilated and either sluggish or rigid. The characteristic white eschar of carbolic acid is seen about the lips and within the mouth, and the characteristic odor of the poison permeates the room.

8. *Chloral coma.*—The most characteristic symptom of poisoning from chloral is the early and pronounced cyanosis which usually precedes loss of consciousness. When coma develops it rapidly becomes profound; the temperature is lowered from one or two to several degrees below normal; the pulse is at first soft and slow, becoming rapid and irregular as the patient passes into a more critical state; the pupils are moderately contracted early in the condition, becoming dilated as the coma becomes more profound. The patient is thoroughly relaxed and the respiration is slow. The functions of the entire body are greatly depressed. The pronounced lividity, deep coma, muscular relaxation and the absence of local and localizing symptoms serve to differentiate the condition from brain injury.

9. *Asphyxia from illuminating gas.*—The patient smells strongly of the gas. During the coma the respiration is slow and blowy, pulse slow and weak, pupils sluggish but reactive to light until shortly before death. Temperature subnormal. The history of the case or the odor of gas emanating from the patient will be sufficient to determine the cause of unconsciousness.

10. *Asphyxia from carbon monoxid.*—In poisoning from carbon monoxid the clinical picture is quite different from asphyxia resulting from illuminating gas. The patient is rigid and tremors pass over the body, there is slight cyanosis and frequently a light froth at the mouth. Respiration labored, pulse weak and irregular. The eyes are sometimes open and the patient may roll them about giving the impression of consciousness, when in reality he knows nothing of his surroundings. Vomiting is common and on analysis of the vomitus, carbon monoxid is found. Skin relaxed and covered with cold perspiration. The history of the case having been exposed to carbon monoxid and the peculiar symptoms will determine the diagnosis.

11. *Ptomaine poisoning.*—In poisoning by ptomaines the onset

is gradual, accompanied by severe gastro-intestinal disturbances. Coma is not common and is late in development. The history alone should serve to differentiate the condition.

12. *Coma from lead poisoning* occurs specially in those persons whose occupation exposes them to the fumes of the metal. The onset of coma is gradual and preceded by convulsions, colic, purging and vomiting. The presence of lead in the urine and the blue line on the gums will distinguish the condition from other forms of coma even if no history is obtainable.

13. *Coma from belladonna* is often preceded by convulsions and delirium. The temperature is raised, respiration slow and deep until the patient is in extremis, pulse rapid. Pupils are widely dilated, skin hot and dry and covered with the characteristic rash produced by the drug.

14. *Hyocyamus and its alkaloids* dilate the pupil though not as widely or quickly as belladonna. Extreme dryness of the mouth and throat is present, with flushed face. The pulse and respiration are slow and the temperature may show a rise though the diaphoresis produced by the drug would tend to reduce this again. Incoördination is present before the patient loses consciousness and later on pronounced muscular relaxation is present.

C. COMA FOLLOWING CHRONIC DISEASE AND DUE TO TOXINS ARISING WITHIN THE BODY.—Nephritis and diabetes are two conditions which we should never fail to consider when examining unconscious cases. The enfeebled condition which these two diseases often produce predispose the sufferer, especially in cities, to accident. But, on the other hand, the fact that albumin or sugar is found in the urine of an unconscious case should not cause us to jump at the conclusion that the cause of coma is necessarily the unconsciousness produced by the disease. Other forms of unconsciousness should be excluded as far as possible, the patient carefully watched for further developments, and the proper treatment for diabetic or uremic coma instituted.

15. *Uremic coma.*—Uremic coma is usually of gradual onset, being often preceded by headache and malaise. Delirium and convulsions are usually present preceding absolute unconsciousness. Albumin and tube casts are found in the urine but their presence aside from a history of nephritis or other symptoms of the disease is of little diagnostic value since they occur so frequently in injury

and diseases of the brain and other conditions. If the disease has advanced far enough to produce coma, we are almost sure to find other symptoms of the disease such as edema of the legs, edema beneath the eyes, the facies peculiar to chronic nephritis and the characteristic urinous odor to the breath. Uremia may simulate the symptoms of brain injury more closely than any other condition. Variations of the pupils, apparent paralysis of the extremities or of one side of the face, ocular deviations, or conjugate deviation of the head and eyes not infrequently occur and may lead one, especially if wounds or abrasions of the scalp exist, into making a diagnosis of intracranial hemorrhage or brain injury when the symptoms are due entirely to uremia. These symptoms, however, are found to change in character and position (a supposed paralysis shifting from one member to another) which is not the case in organic lesions of the brain. A careful history of the case, the lack of permanency in the false localizing symptoms and the presence of other evidences of advanced nephritis will usually suffice in making the differential diagnosis.

16. *Diabetic coma.*—In coma due to diabetes the onset is variable; it may come on rapidly following exertion or it may be gradual and preceded by nausea and vomiting. Sugar in large quantities is found in the urine though this is by no means pathognomonic. It is one thing to determine that the patient has diabetes and quite another to prove that the unconsciousness is a direct result of the disease. Acetones are of more value in diagnosis than ~~in~~ sugar. The blood picture in diabetes is often typical ; hyperglycemia and polycythemia are usually present. Moderate leukocytosis and beta-oxybutyric acid are almost constant in diabetic coma. A high percentage of fat is often found in the blood and the red corpuscles fail to take the stain as in normal blood. Boils or carbuncles, or scars indicating their previous existence, are sometimes found on the skin. The harsh dry skin, sometimes showing diabetic bronzing, localized gangrene associated with arteriosclerosis, onychia, etc., when present suggest diabetes. The breath often has a peculiar sweet, heavy odor, characteristic of diabetes. The history of the case, examination of the blood and urine, and the presence of some of the symptoms of diabetes above mentioned will usually disclose the cause of the coma. In examining the blood of these cases it is essential to

draw off a sufficient quantity (8 or 10 c.c.) to enable the laboratory man to conduct a satisfactory chemical and microscopical examination.

D. REFLEX COMAS AND THOSE PRECEDING OR FOLLOWING ACUTE INFECTIONS.

17. The *acute exanthemata of childhood* are sometimes ushered in by *convulsions and coma.* This is particularly true of scarlet fever. The eruption of scarlet fever makes its appearance within twenty-four hours, following which the coma passes off. The temperature in the preëruptive stage is usually high (104 or 105). It is often impossible to make a positive diagnosis before the eruption makes its appearance, yet by inquiring into the history of exposure to infection and the absence of cranial trauma together with the history of one or two convulsions followed by coma and high temperature should lead us to suspect an acute infection.

18. *Coma due to dentitional or gastrointestinal disturbances* in children will usually give a history pointing to these disorders prior to the onset of unconsciousness. Coma is usually preceded by convulsions. The temperature is lower and the pulse slower than usually found preceding the acute exanthemata.

19. *Comatose states developing during acute infections* usually come on late in the course of the disease and in most cases the preceding history will be all that is necessary for differentiation. The low muttering delirium of typhoid and similar conditions is too characteristic to be mistaken.

E. DISEASES AND NEUROSES OF THE CENTRAL NERVOUS SYSTEM ARE NOT INFREQUENTLY ACCOMPANIED BY COMA and it is often difficult to determine whether the patient fell unconscious because of the disease or whether unconsciousness is the result of head injury sustained in an accidental fall.

20. The *coma of hysteria* usually occurs in women, comes on rapidly and may be preceded or alternate with delirium. The patient frequently falls with the onset of unconsciousness, but it will be noted, usually falls in a convenient place and is not injured in the act. The pulse respiration and temperature are normal except in instances in which there has been severe muscular exertion such as occurs in hysteria major. In such cases the respiration may be rapid but is free and not stertorous, and the temperature may show a degree or so of elevation with a slightly accelerated pulse. When the examiner raises the eyelid for inspection, the

eyeball presents a characteristic rolling movement, with attempt on the part of the patient to keep the pupil under cover of the margin of the lid. Muscular resistance from the orbicularis palpebrarum is also encountered in raising the eyelid. The pupils are usually normal and react to light; muscular exertion, however, may cause them to be slightly dilated. Suddenly inflicted pain will usually elicit prompt response and often results in the surgeon being roundly scored for his trouble. In rare instances however the patient will withstand the most severe supra-orbital pressure, responding only with the use of the electric brush. Evacuations of the bladder or bowel never occur in hysterical coma.

A clever malingerer may simulate any form of coma but fortunately those who attempt feigning are usually not well enough versed in symptomatology to produce a consistent picture. The eyeball is never fixed in the malingerer and the pupil reacts normally to light. Sudden and repeated pain will elicit response as in hysteria. Convulsions and rigidity are much less common than in hysteria.

The exhibition of apomorphine will cause the hysteric or feigner to forget about his unconsciousness as soon as he becomes actively engaged with the effects of the drug. Other causes of unconsciousness may readily be excluded by the absence of the symptoms which accompany real coma and the fact that the patient can be completely roused.

21. *Unconsciousness due to epilepsy.*—The ordinary epileptic fit is of short duration, in fact the surgeon seldom arrives on the scene in time to witness the attack. If the history of the case can be had or the onset of the attack is observed there will be little difficulty in differentiating the condition from other causes of coma. The patient often presents a semicomatose condition following the attack or may show delirium or become actively maniacal. The tongue is often bitten during an attack and in many cases old scars are present on the tongue indicating injury to the organ in previous convulsions. In old cases of epilepsy it is common to find numerous old scars on the scalp and face, the result of injuries sustained in previous attacks. The history of the case, the short duration of the unconsciousness and the absence of localizing symptoms will distinguish the condition from other forms of coma. In status epilepticus, however, one attack follows so closely upon another that unconsciousness is continuous and it may be almost im-

possible without the history of the case to differentiate between this condition and an acute cerebral lesion. It should be remembered, in this connection, that intracranial hemorrhage may result from an epileptic attack and the manner in which these cases fall may produce fracture of the skull or meningeal hemorrhage.

22. *Apoplexy.*—Differentiation between apoplexy and traumatic brain injury may under some circumstances be extremely difficult. The history of the case should be inquired into most carefully with special reference to the manner in which coma developed. Apoplexy is one form of brain injury and hence the symptoms will be similar to those occurring as a result of brain injury from external trauma. When the cortex is irritated, as occurs in meningeal hemorrhage or pressure from fragments, the paralysis is more likely to be preceded by local spasm;—when the damage is done to the tracts leading from the cortex as is usual in apoplexy, the paralytic symptoms are preceded by only slight spasm if convulsive movements are present at all. The local symptoms of brain injury should be carefully looked for and excluded if there is any question as to the cause or site of the hemorrhage.

Cerebral embolism, thrombosis and hemorrhage are included under the heading of apoplexy, yet the three conditions are so different in some respects that their characteristics will have to be considered separately. *Cerebral embolism* is seen oftenest between the ages of thirty and fifty, occurs during physical activity or when strain is thrown upon the heart from any cause. A previous history of articular rheumatism or chorea complicated by cardiac disease is usually obtainable. If the heart is auscultated murmurs will usually be noted, since the condition is most often the result of vegetative endocarditis involving the mitral valve. The onset of coma is very sudden, being caused, as a rule, by occlusion of the middle cerebral artery. The lesion may be irritative or paralytic with corresponding motor increase or motor loss. The cerebral edema surrounding the area of anemia usually clears up within a few days, with corresponding diminution in the extent of the symptoms. The only part of the brain suffering permanent damage is that portion previously supplied by the occluded artery. Abscess or softening frequently follows. The previous history of the case, the presence of endocarditis, the onset of coma, and the absence of cranial trauma will usually be sufficient to differentiate.

Cerebral thrombosis occurs most frequently between the ages of twenty and forty or after sixty-five. When it occurs between twenty and forty it is usually due to syphilis, and other symptoms of this disease will be present. Other debilitating conditions however may be responsible for thrombosis, such as tuberculosis, cancer, primary anemia, hemorrhage, diabetes and pregnancy. When thrombosis takes place after sixty-five it is almost invariably due to arteriosclerosis. It usually occurs during sleep or similar states of inactivity in which the blood pressure is lowered or the viscosity of the blood increased. The history usually shows previous attacks of dizziness or periods of weakness or paresthesia in an extremity lasting a few hours or days. The onset of coma is, as a rule, gradual and progressive and since the pathologic process most frequently occurs in the cortical veins the symptoms are at first irritative in character. Aside from weakness, the common aura consist of attacks of vertigo, aphasia, local peripheral muscular twitchings or spasm, or disturbances in sight. The lesion produces more damage than takes place in embolism and the symptoms indicate progress as the thrombus extends in the vessel, including additional branches. In some instances the thrombus may extend around under the base of the brain involving centers of the opposite side. Thrombosis in the aged is a frequent source of cerebral softening; abscess is relatively rare. The gradual onset of unconsciousness, progressive nature of the localizing symptoms, lowered blood pressure, and the previous history of the case should differentiate the condition from traumatic head injury.

Cerebral hemorrhage most often occurs between the ages of forty and sixty. It may take place prior to forty in persons suffering from premature arteriosclerosis or in conditions which predispose to arterial disease or sudden elevation of blood pressure. The onset is, as a rule, sudden and the cerebral damage is done at once; the usual seat is the lenticulo-striate artery with accompanying injury to the internal capsule which results in a hemiplegic syndrome. If the hemorrhage is sufficient to break into and flood the ventricles the symptoms will be bilateral from the first and usually terminate fatally. In the common form of cerebral hemorrhage the patient falls as if struck down, and becomes rapidly unconscious with turgescence of the face and neck. Hemiplegia, variations in respiration, flaccidity, sphincteric disturbances and conjugate deviation, are some of the symptoms which may occur in both apoplexy and fracture of the skull with cortical pressure, so that it is impossible in some cases to distinguish between the two conditions by the general and localizing symptoms alone. The similarity in the localizing symptoms of the two conditions is due to the similarity in the lesions. In apoplexy however the paralysis is more likely to involve the entire side (i. e., hemiplegia) because of the small territory occupied by the fibres as they pass through the internal capsule; in fracture of the skull it would require an unusually large clot or area of depressed bone to include all the cortical centers for the entire opposite side of the body. In apoplexy the extent and degree of paralysis rarely increase, because the damage to the internal capsule is completed at the time of the stroke; in meningeal hemorrhage it is not uncommon to see the region of paralysis extend and become more pronounced as the clot grows larger, involves more centers and produces greater pressure. Monoplegias therefore are more common in cortical lesions than in cerebral hemorrhage. Monoplegic forms of cerebral hemorrhage however are sometimes seen in instances in which some small artery other than the lenticulo-striate is ruptured producing paretic or irritative symptoms according to the seat of hemorrhage. The ingravescent form of cerebral hemorrhage is extremely rare, the symptoms are gradual and progressive in onset, and it usually terminates within a few days.

The similarity in the two conditions may be extremely confusing at times, especially if an apoplectic has sustained a scalp wound or other head injury in the fall accompanying the stroke. Most careful inquiry should be made into the history of the case and the onset of unconsciousness. A careful examination of the head for the local symptoms of fracture of the skull will often clear the diagnosis in doubtful cases. Fracture of the skull with localizing symptoms usually shows more pronounced and earlier pupillary inequalities than occur in cerebral hemorrhage.

23. *Cerebral syphilis* usually occurs between the ages of twenty-five and fifty. When coma develops in the course of this disease it is usually slowly progressive and not deep at the onset. Severe headache, especially during the afternoon and evening, pain in the shin bones, monocular palsies and the symptoms of cerebral thrombosis above referred to commonly precede loss of consciousness. Other symptoms of syphilis are likely to be present if the coma is due to this disease. In some instances a definite history

of specific infection is obtainable but on the other hand the determination of syphilis should not lead us to consider this the cause of coma without a thorough examination for and exclusion of fracture of the skull, especially in cases which are known to have met with accident. In doubtful cases the Wassermann blood-test should be made.

24. *Cerebral meningitis.*—It is uncommon for cerebral meningitis and cerebral trauma to be associated or confused. Acute cerebral meningitis is usually caused by the pneumococcus, Weichelbaum's meningococcus, or occurs as a part of other acute infectious processes especially in childhood. The history of the disease preceding unconsciousness is almost invariably obtainable. Headache, vertigo, chills or general convulsions precede the rapidly deepening coma. Rigidity of the neck muscles with retraction of the head is present and if the patient is not absolutely unconscious, motion of the head will be resisted and cause him to cry out. Opisthotonos develops when the spinal membranes become involved. The temperature is usually raised though it may be subnormal from the onset. The pulse is slow and irregular and the respiration increased. Unilateral convulsions may occur. The leukocyte count is high. Lumbar puncture is of great value in diagnosis. The history of the case, characteristic symptoms, and absence of head trauma will usually render the diagnosis easy.

25. *Abscess of the brain.*—Abscess of the brain may occur at any age. Two-fifths of the cases are the result of suppurative otitis media; suppurative processes within the chest are responsible for a large proportion of the remaining three-fifths. The usual early symptoms resemble those of embolism. The middle stage of cerebral abscess is quiescent. The third stage develops when rupture occurs. Absolute coma occurs late and is gradual in onset except when it accompanies rupture and then the symptoms simulate those occurring in both meningitis and cerebral hemorrhage.

26. *Tumor of the brain.*—The history shows headache, cerebral vomiting, choked disc, and a slow pulse. The onset of coma is slow. When the history can be obtained the condition should never be mistaken for brain trauma.

27. *Apoplectiform and epileptiform convulsions* occur chiefly in arterial diseases of the brain such as seen in alcoholism, uremia, paretic dementia, tumor of the brain and disseminated sclerosis. The most common form is that occurring in chronic alcoholism.

The essentials of the condition are the convulsions followed by coma, in some cases, with symptoms which at first appear as localizing symptoms but are evanescent in character. The history of previous disease and the transitory character of the symptoms will render the diagnosis easy.

Treatment.—Each case must be considered by itself, with special reference to the different symptoms displayed. For example: a given case may show a scalp wound and bony depression in the region of the middle meningeal artery with profuse and dangerous hemorrhage, so that operation with elevation of the fragments and hemostasis is the prime requisite of treatment. Another case may show the most profound shock without signs of increased intracranial pressure, the condition being such that the added physiological insult of operation could have only a fatal outcome if performed before reaction takes place. In this type of case stimulation is indicated regardless of localizing symptoms in order that the patient may regain sufficient resistance to withstand the necessary surgical procedure. Still another case may show but little shock and only semiconsciousness, with symptoms of increasing intracranial pressure and paralysis indicating the region of cortical damage. Under such circumstances expectant treatment might soon see the patient in such a state of collapse that operation would be useless, or if this did not occur the chances of complete cortical recovery might be reduced with every hour of delay. The most seasoned surgical judgment and acumen are necessary to determine when to operate and when to leave the patient surgically alone. In the treatment of fracture of the skull we must keep in mind the unfavorable late symptoms and sequelæ which so often follow head injuries, especially when unoperated.

If the condition of the patient does not call for immediate operation he should be put to bed and measures instituted for the alleviation of shock. Hot water bottles or some other form of artificial heat is essential in the treatment, but the greatest care should be exercised to avoid burning the patient, since with unconsciousness the protective pain and temperature sense is absent. The patient may be wrapped in blankets previously warmed by the fire. The electric heat blanket is of great advantage, but is usually available only in hospitals. It is essential that a chart be begun as soon as possible; it should contain records of the pulse, respiration and temperature at frequent and regular intervals;

pupillary changes and alterations in the depth of unconsciousness, especially a return to the unconscious state after a lucid interval, should be noted. If general or local spasms occur they should be entered, and when the necessary apparatus is at hand records of the blood pressure should be made every hour or every two hours until the necessity of operative intervention is determined. The need of intelligent and competent observation and nursing is too apparent to require special mention.

No hard and fast rule can be laid down as to the use of stimulants and sedatives; it will be necessary to watch the patient carefully and use drugs as indicated. Strychnine sulphate is a valuable stimulant but must be used with due regard for the possible harm it may accomplish in intracranial hemorrhage. In some cases the collapse may be so critical that stimulation is demanded to avert death, even though there are indications of increased intracranial tension. In such instances stimulation may render operation possible, thus affording the surgeon opportunity for the removal of meningeal clot. Nitroglycerine, in some cases, will minimize the danger which may accompany the use of strychnine. Pain or extreme restlessness may call for the exhibition of opium, though it is usually unwise to use this drug in head injuries, especially before the diagnosis is properly established. We may otherwise obscure symptoms of the greatest importance; thus a return to the unconscious state, a most significant happening, might not be recognized if the patient had just previously received a hypodermic injection of morphine. Bromides, chloral and codeine are at times useful. In cases of suspected fracture or those in which the fracture is diagnosed but operation is not deemed advisable, the patient should be kept at rest in bed for at least ten days and carefully watched for untoward symptoms. A chart should be kept, as previously described, for the purpose of accurately determining the course the case is taking. Absolute rest and quiet are essential. If the patient is unconscious sufficiently long to allow the bladder to become distended the catheter should be used at regular intervals.

Fracture of the skull may be rendered compound by scalp wounds or by the line of fracture in the base establishing communication with the nasal or oral cavities, or by involvement of the petrous portion of the temporal, and when such is the case measures should be instituted to prevent, as far as possible, the passage of infection from these cavities to the meninges, and no form of treatment is permissible which produces an increased pressure (either fluid or gaseous) within these cavities.

The Ear.—Discharges of blood or serum from the ear call for a loose, copious gauze dressing which will absorb the fluids as fast as they come from the external auditory canal. The common practice of douching the canal with antiseptics is pernicious, since by this means infection is more often carried inward than is sterilization accomplished. The canal should not be plugged with cotton, as commonly practiced, since this can only tend to dam the fluids back instead of allowing their free and prompt escape. If clots of blood form within the external auditory meatus they should be removed with a sterile ear-hook so that the canal may be kept open. Fracture of the base, allowing the escape of blood within the cranium or into the petrous portion of the temporal, is much more favorable in outlook if this blood makes its escape through the ear.

The *upper part of the nasal cavity and of the naso-pharynx* are sometimes the seat of basal fractures which establish communication between these cavities and the meninges. When such is the case, as commonly indicated by hemorrhage or the escape of cerebrospinal fluid, the nose and mouth should receive the most careful attention. The nose should be kept free and clean by the removal of clots forming in the lower part of the nose. Alkaline washes, when properly used, may facilitate the removal of these clots, but violent douchings or syringings should be avoided, lest they carry infection into or through the line of fracture. For similar reasons the patient should not be allowed to blow his nose, and if coughing occurs it must be controlled by sedatives. Screatus will draw the secretions through the posterior nares and, since it is accompanied by the same result, a negative air pressure within the nasal cavities is to be recommended instead of blowing the nose. Hemorrhage from the nose, unless severe, does not call for checking, and plugging of the nostrils only results in the accumulation of foul and infectious clots within the nasal cavities. The mouth should be frequently washed out and the teeth cleansed with potassium chlorate tooth paste. The cleansing and treatment of scalp wounds has already been described; when fissures or depressions exist at the bottom of the wound irrigation is contraindicated.

Operative Treatment.—Operative treatment is called for;—in the treatment of scalp wounds, for the elevation of depressed fragments in either simple or compound fracture of the vault, for alleviation of meningeal hemorrhage, for the removal of foreign bodies within the skull, for the correction of secondary complications such as cortical irritation resulting from old scars, and for the treatment of tumors, abscesses or softening. In depression of the vault it is often possible to elevate and remove the fragments with a heavy rat-tooth forceps; but in other instances it may be necessary to trephine on the solid side of one of the margins of the depression, to introduce an elevator beneath the fragments. A simple fissure without localizing symptoms or indications of intracranial pressure does not necessarily call for opening of the skull, but in many cases the safest plan will be the exclusion of meningeal complication by operative intervention. Of the various methods, however, which have been employed for the removal of a meningeal clot, the osteoplastic flap is the most satisfactory. It is often difficult to accurately determine the site of the hemorrhage, even when localizing symptoms are present, and if an opening in the skull no larger than that produced by the ordinary trephine is made, the chances of failure in locating the clot are many. The change in recent years from simple trephining to the use of the

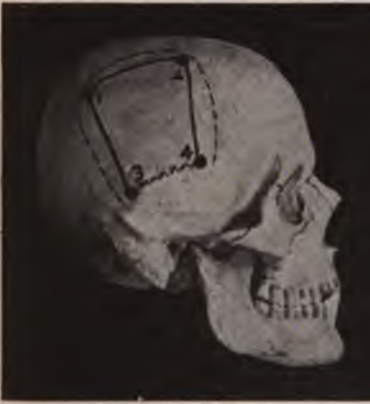

Fig. 533.

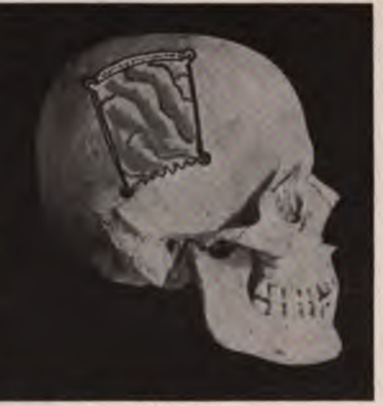

Fig. 534.

Fig. 533.—Diagram indicating the steps in opening the skull by means of an osteoplastic flap. *1*, *2*, *3* and *4* indicate the positions of trephine openings. Solid lines indicate division of skull. Line *3-4* indicates where the flap is turned back. Dotted line indicates skin incision.

Fig. 534.—Shows the motor area exposed when the flap is turned back.

osteoplastic flap has materially reduced the percentage of operative failures. In making an osteoplastic flap a U-shaped incision with the convexity upward is made through the scalp and down to the bone, the skull is exposed and two small trephine openings are made at the upper angles of the quadrilateral section of bone to be displaced. A grooved director is then introduced into one of the openings and passed between the dura and the skull in the direction of the opening in the adjoining angle; by this means a Gigli wire saw is passed from one opening to the other and the bone between the two cut with the divider in place to protect the meninges. If the upper border of the bone flap is beveled at the expense of the inner table, while being cut with the saw, it will prevent subsequent inward displacement. The vertical sides of the bone flap are then made by cutting the skull with DeVilbiss forceps, beginning at the trephine openings. After the three sides are completed the base is broken and the flap turned back. The DeVilbiss cutting forceps may be used instead of the saw in connecting the trephine openings, the bone having been previously separated from the underlying dura. Those skilled in the use of

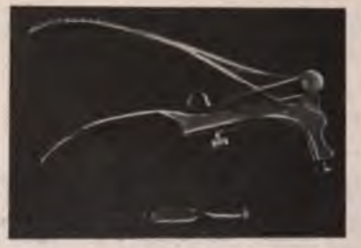

Fig. 535.—DeVilbiss bone-cutting forceps used in making the osteoplastic flap of skull and scalp.

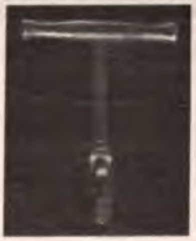

Fig. 536.—Small trephine employed in making an osteoplastic flap. The opening made with this instrument may be used to introduce the Gigli saw, or a bone-cutting forceps such as the DeVilbiss may be used. (See Fig. 535.)

the chisel and mallet divide the bone with considerable facility, though this procedure is not to be recommended because of the shock so commonly produced by the hammering. (For the course of the middle meningeal artery and common sites of meningeal hemorrhage, see "Surgical Anatomy," page 396.) After the flap has been made and turned back the clot should be removed with the least possible trauma to the underlying brain. The artery from which the hemorrhage occurred is to be secured and ligated. Subdural clots or bleeding may be present, necessitating the opening of the dura to reach the collection of blood. In closing the wound the dural edges should be carefully approximated with fine suture material after all hemorrhage has been properly controlled. In cases of marked increased intracranial tension it may be impossible to bring the edges of the dura together, or if such is done, the object of the operation is to some extent defeated, if it has been performed for decompression. In such instances the dural defect may be provided for by the transplantation of a section of fascia lata. This prevents adhesions between the brain and scalp and at the same time allows an increase in intracranial capacity Plastic sliding operations on the scalp may be performed when the osteoplastic flap cannot be brought back into accurate apposition because of extrusion of the brain and dura. Lumbar puncture will facilitate closure of the scalp and skull in an otherwise difficult case and is attended by less danger if the skull is open at the time the cerebrospinal fluid is withdrawn. Cushing's crossbow incision may be employed in opening the posterior fossa, though the results of decompressive operations in this region have not been as satisfactory as one might wish. The positions of the sinuses in this part of the skull must be kept in mind when operating in this region.

Prognosis.—The prognosis of head injuries is as varied as the subject itself. The outlook will depend largely upon the damage sustained by the cranial contents at the time of the accident and, inasmuch as it is sometimes most difficult to determine the extent and severity of this damage, it will be proportionately hard to state just what the outcome may be. In addition to the traumatic elements we will have to consider the chances of infection and meningitis when the fracture is compound. It is next to impossible to state in a given case whether or not the patient will in the future develop traumatic epilepsy, suffer from chronic headache, vertigo and other late symptoms, or that he will or will not develop cerebral tumor, abscess, gumma or softening. In a general way it may be stated that the more severe the trauma, and the more pronounced the symptoms, the greater the danger of an early, fatal termination. The prognosis as to life is good in cases which survive the first forty-eight hours following the injury. Rigidity of the pupils, especially in dilatation, is commonly followed by death. Pronounced disturbances in respiration, temperature and pulse whether early or late in the case, render the prognosis grave. The mortality and the development of sequelæ have been materially reduced by operation in selected cases. Fracture of the base more often produces death than fracture of the vault. Of fractures of the base those involving the posterior fossa have the highest mortality, those of the anterior fossa the lowest, while fractures of the middle fossa occupy an intermediate place. This difference in mortality is largely due to the positions of the important basal ganglia, and to the fact that hemorrhage into the anterior or middle fossæ usually makes its escape without difficulty through the mouth, nose or ears. Meningitis more commonly follows fracture of the anterior and middle fossæ, though the dangers from this complication by no means equal the deadly effect of pent-up hemorrhage within the posterior fossa. The development of new and significant symptoms during the course of the case may so alter the general aspect in diagnosis, treatment and prognosis that it will be unwise for the surgeon to make any definite forecast early in the condition. A most valuable aid in prognosis will be found in a carefully kept and complete chart which points accurately to changes occurring in the case and shows whether the symptoms are increasing in severity, or, on the other hand, are becoming less pronounced.

Late Symptoms and Sequelæ Following Head Injuries.—The immediate recovery and the after-effects in fracture of the skull do not bear any constant relation to each other, nor are the late conditions developing in the course of the case necessarily proportionate to the extent and severity of the original damage.

The symptoms of tumor, gumma or abscess of the brain may make their appearance months or even years after the original injury, following an interval of apparent recovery. In other instances the symptoms of the sequelæ may develop before the patient has recovered from the acute condition of fracture of the skull.

The unfortunate condition of some of these patients is known to those who have attended large clinics for any considerable period. The head pains, epileptic convulsions, subjective sensory disturbances, psychic changes or paresthesis often unfit the sufferer for the sociologic demands of his surroundings, and he haunts the clinics or passes from one surgeon to another with the persistent hope that some new operation or different type of surgical procedure may afford him relief. The peculiar way in which these patients attempt to figure out the details of intracranial derangement and their fixed opinions concerning the manner in which the surgeon should correct the trouble, are often characteristic. Epilepsy following fracture of the skull is not uncommon and often assumes the Jacksonian type. When the convulsions are focal in character and have not been allowed to persist for a period of more than two years the chances of recovery, as a result of operative intervention, are good if the causative cortical irritation is corrected or the area of the cortex in which the convulsion begins, is removed. When the non-focal form of epilepsy follows fracture of the skull it is not so easily controlled, the treatment being, as a rule, medical.

Chronic headache often begins in, or is confined to, the region of the original injury and may be dependent upon cortical irritation. When such is the case, operations for its relief may be successful, as in focal epilepsy. In other instances the headache is general and the outlook for surgical relief is not so hopeful. Pain in the nerves of the scalp, which is sometimes produced by cicatricial contraction, or pain in some of the cranial nerves, as a result of injury, is not, strictly speaking, headache, and should be dealt with according to the peculiarities of the individual case. Chronic headaches following fracture of the skull deserve the most careful neurological study in order that the cause may be determined, when possible, and relief afforded.

Vomiting, vertigo, and disturbances in hearing are sometimes persistent and extremely distressing to the patient. Little in the way of radical treatment can be accomplished for these conditions; sedatives, depressants and proper hygienic surroundings are about all that can be done for their relief, with the hope that they will in time lessen in degree and finally disappear. When these symptoms occur as a result of cerebral abscess, tumor or softening, the treatment becomes that of the causative lesion. Psychic changes are not infrequently observed following fractures of the skull, particularly in injury to the frontal lobes. The extent of the frontal lobes, however, and the variability in the proportion existing between lesion and symptoms renders the subject of localization extremely difficult unless local symptoms exist pointing to the exact region of damage, and even in instances in which a visible depression on the forehead indicates the site of fracture and cortical displacement, the results of operation are by no means uniformly satisfactory.

The patient may show a simple weakness of intellect, the comprehension being dull and slow, or he may present an irritability and temperamental change entirely foreign to his disposition prior to the accident. Lassitude and aversion to either physical or mental activity are common among the psychic changes. It not uncommonly happens that the patient is persistently possessed of abnormal fears and apprehensions regarding his physical welfare, domestic relations or business responsibilities. The fear of failure is sometimes such an obsession that the patient refuses to even attempt anything in the way of resuming his former occupation. It should not be understood that such fears are without any real foundation in fact, yet when they do exist it is usually noted that the real degree of unfitness is by no means proportionate to his own sense of incapacity. In rare instances insanity may follow.

CHAPTER XXXII.

FRACTURES OF THE STERNUM.

Surgical Anatomy.—The sternum is rarely fractured. Firstly, because of the protection afforded by the arms in case of accident, and secondly, because of its situation and structure. It is composed of a soft, spongy tissue encased in a layer of compact bone, and is supported by the ribs and costal cartilages which act as a series of springs which absorb and modify shock.

The sternum is usually ossified from six centers; one each, for the manubrium and ensiform appendix, and four for the gladiolus.

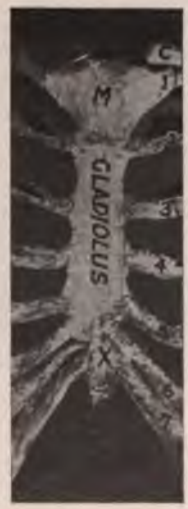

Fig. 537.—The sternum. *M.*, manubrium; *X.*, xyphoid cartilage; *C.*, clavicle. The costal cartilages are numbered in order.

Considerable variation occurs in the ossification of this bone. The lower sections of the gladiolus are not uncommonly ossified by two centers for each segment, and in anomalous instances lack of fusion between these lateral centers may result in a foramen or fissure in the lower part of the second portion of the sternum, even in adult life. This condition might be mistaken for a fracture if one is not acquainted with the anomaly. The centers of ossification in the sternum make their appearance in order from above downward, the first being seen as early as the fifth fœtal month, while the center for the lower segment of the gladiolus is often not present until the second year. The center for the xyphoid cartilage may make its appearance anywhere between the second and eighteenth years. Fusion of the different segments of the sternum begins at about puberty in the lower end of the gladiolus, and proceeds upward until the process is completed at about the twenty-fifth year. The xyphoid joins the gladiolus at about forty. The period at which fusion occurs between the manubrium and gladiolus is variable. They are usually continuous on the surface after middle life though the center of the articulation often remains soft even in the aged.

The anterior mediastinum with its contents lies directly behind the sternum.

The pectoralis major is attached to the anterior surface of the bone. The sternomastoid, sternothyroid and sternohyoid are attached to the upper end, while the abdominal muscles are attached either directly or through their aponeuroses to the lower end of the bone. The diaphragm and triangularis sterni find attachments to the lower portions of the posterior surface.

The anterior mediastinum with its contents lies directly behind the sternum. The heart lies directly behind the lower two-thirds of the sternum (excepting the xyphoid cartilage). The pericardium is separated from the bone by the remains of the thymus gland above, and a small quantity of areolar tissue below. The junction of the first and second pieces of the sternum may be felt as a transverse ridge on the bone, passing between the attachments of the second costal cartilages.

Violent hyperextension, or overflexion of the spine, particularly the latter, may produce fracture of the sternum. The violent impact of the chin against the upper portion of the bone is said to have produced the condition. A blow on the chest may, in rare instances, produce fracture. Gunshot injuries of this bone are not uncommonly seen even in civil life.

In the aged, when ossification invades the costal cartilages, and the chest as a whole is more rigid, fracture is more easily produced; but, on the other hand, the occupation and mode of life of those advanced in years expose less to trauma. A number of irregular types of fracture have been reported in which the condition was diagnosed as compound, comminuted, multiple or longitudinal. These types of fracture, however, are extremely unusual in the sternum, the great majority being simple and transverse at, or near, the junction of the first and second pieces of the bone. The next most common deformity is one in which the upper fragment is displaced forward and slightly overlaps the lower piece. The common deformity consists in a displacement of the lower end of the upper fragment behind the lower fragment. The deformity is so characteristic and pronounced that a diagnosis can usually be made by inspection alone.

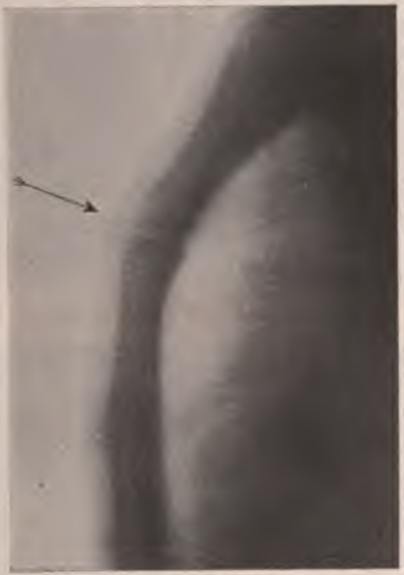

Fig. 538.—Fracture of the sternum. Arrow indicates position of fracture which is in perfect reduction. Case of Dr. N. A. Thompson.

Sometimes, however, a simple transverse fracture may exist without displacement, when the condition can only be recognized by palpation, pressure being made first on one fragment and then on the other. The next most common site of fracture is at or near the junction of the first and second pieces of the gladiolus and resembles closely the more usual fracture occurring at Ludwig's angle.

Symptoms.—The close relation existing between the sternum and thoracic viscera frequently results in complications involving these structures. It is seldom that we find fracture of the sternum unaccompanied by other injuries, so that the symptom-complex frequently includes conditions such as fracture of the ribs, fracture of the spine, penetrating wounds of the chest, etc. In fracture of the sternum the patient usually assumes a hollow-chested attitude which is characteristic both in the erect and recumbent positions. Respiration is usually painful, rapid and superficial, resembling that seen in fracture of the ribs.

Inspection and palpation of the chest usually reveals the characteristic deformity in the upper part of the sternum. When no deformity exists, crepitus is, as a rule, elicited without difficulty and in some instances may, by means of the stethoscope, be recognized with every respiration.

Dislocations between the first and second portions of the sternum, in young persons, produce practically the same symptoms except that crepitus is more likely to be cartilaginous. The distinction between the two, however, is clinically of little importance. Cyanosis and dyspnœa may occur as the result of direct pressure from the displaced fragment.

Treatment.—When deformity is absent from the first, or if reduction has taken place spontaneously as sometimes occurs in normal respiration or in coughing, the only indication in the treatment is immobilization, which is most satisfactorily accomplished by strapping the chest with adhesive plaster in a manner similar to that employed in fracture of the ribs. Direct pressure on either of the fragments may be obtained by a pad of gauze properly placed and held in position by adhesive plaster placed diagonally across the chest. A plaster cast including the chest and shoulders may be employed instead of the adhesive, although it does not accomplish the purposes of fixation any more satisfactorily.

When deformity is present, it should be corrected before the chest is fixed. The reduction of displacement is accomplished in all instances by upward traction on the upper fragment, and downward traction on the lower. As a rule this is effected by posture, the traction and countertraction being applied indirectly through the muscles and other portions of the thorax.

If the patient is placed on a table in the dorsal position with head and shoulders over the edge so that hyperextension of the spine is accomplished, reduction will usually follow without further manipulation of the fragments. Raising the arms above the head and direct pressure on the projecting fragment will facilitate correcting the deformity when simple hyperextension of the spine proves insufficient. After the fragment has been brought into proper position the chest is fixed as previously described.

Operative Treatment.—Various methods have been described for the open treatment of these deformities when simpler methods have failed to accomplish reduction, but it will be unnecessary to enter into the minutiæ of these surgical procedures since they all are based on the same principles of traction, counter traction and manipulation after the fragments have been exposed by incision. Elevation has been accomplished by means of screws inserted into the depressed fragment. As a rule it will not be a difficult matter to pry the depressed portion of the sternum back into position with some strong instrument such as a periosteal elevator. The greatest care should

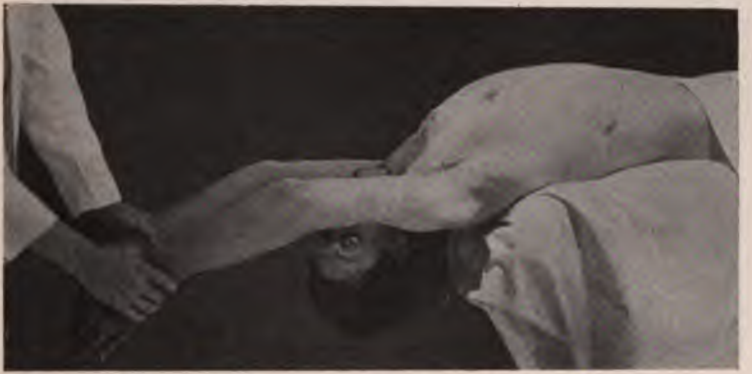

Fig. 539.—Method of correcting deformity in overriding fracture of sternum.

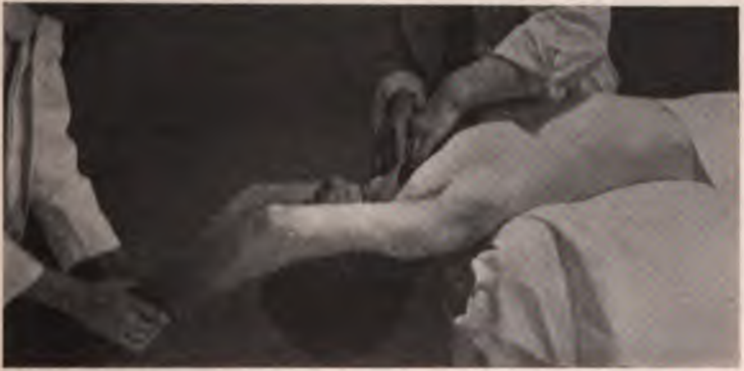

Fig. 540.—The method shown in Fig. 539 has been supplemented by direct upward pressure on the inner ends of the clavicles with the finger tips.

be exercised not to insert the instrument too far or in any way, either by cutting or laceration of the tissues, to open the pleural or pericardial sacs. In operating in this region we should bear in mind the course of the internal mammary artery one-half inch external to, and parallel with the lateral border of the sternum. If the origin of the pectoralis major interferes with the operative manipulations the fibres should be cut away so that the fragments are properly exposed. When reduction has been accomplished the incision is to be closed without drainage, and provision made in the fixation apparatus for the subsequent dressing of the wound during the after-treatment.

After-Treatment.—Fixation of the chest should be maintained for from six to eight weeks following the accident and heavy work or violent exercise forbidden for another two or three weeks. Different types of steel braces and apparatus have been used with success to immobilize the chest and neck though they are seldom called for in a simple case.

Prognosis.—The prognosis of simple, uncomplicated fracture of the sternum is good both as to life and function, but the frequency with which this fracture is associated with severe crushing injuries, such as fractures of the spine and complications of the thoracic viscera, renders the outlook variable, since the prognosis in these instances is that of the complication rather than the fracture itself.

CHAPTER XXXIII.

FRACTURES OF THE RIBS.

Surgical Anatomy.—The surprising degree of trauma which the ribs are capable of withstanding is the result of their mobility and the natural spring which they possess. The first rib is the shortest, the seventh the longest. They are diagonally placed so that the posterior end of a given rib is at a considerably higher level than the anterior extremity. They increase in obliquity from above downward to the ninth rib, below which they become again more horizontal. The upper seven ribs are connected with the sternum through their own costal cartilages. The next three are attached through their cartilages to the ribs above, while the remaining two are floating. The first rib joins the sternum through its cartilage just below and behind the sterno-clavicular articulation. The second costal cartilage joins the sides of the sternum at Ludwig's angle. The lower border of the pectoralis major leads to the fifth rib, while the first visible digitation of the serratus magnus is attached to the sixth. The lower border of the tenth rib forms, from a surgical standpoint, the lower border of the thorax. The inferior margin of each rib is grooved on its deep aspect for the corresponding intercostal vessels. The sixth and seventh ribs are the ones most frequently fractured. The upper two ribs are more or less protected by the clavicle, while the heavy muscles of the back and the unattached condition of the eleventh and twelfth renders these lower ribs even more capable of withstanding trauma.

The ribs may be broken by direct or indirect violence. The former occurs when the rib is fractured and driven inward at the point of impact; the latter when breaking results from bending, as in forcible compression of the chest wall. The weakest point in the rib is just anterior to the angle, and it is here that fracture most often occurs when the result of indirect violence. The costal cartilages may be broken, a not uncommon site being at their junction with the ribs. The close relations existing between the ribs and pleura account for the frequency of complications involving this membrane and the underlying lung, especially in fractures produced by indirect violence.

When a single rib is fractured there is little tendency toward displacement, since both ends are fixed, and the intercostal muscles maintain its relations with the ribs above and below. When a number of consecutive ribs are fractured there is greater probability of deformity, as is also the case when a single rib is broken in two or more places.

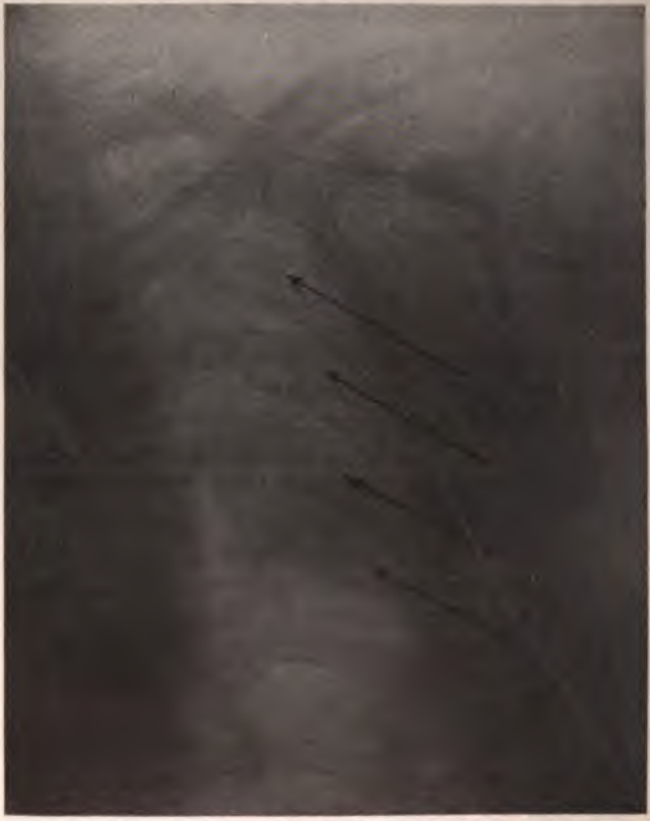

Fig. 541.—Fractures of third, fourth, fifth and sixth ribs.

Dislocation of the ribs may occur at either end, though their structure and the strength of their articulations render fracture by far the more common injury. Dislocation may occur at the vertebral ends of the ribs or at the mesial end of the first, second, eighth, ninth and tenth costal cartilages.

Symptoms.—Pain is a constant symptom, being well localized in the region of the fracture. It is greatly increased by breathing, especially by deep inspiration. Coughing and sneezing render the suffering momentarily more intense. The patient usually stands or sits in an attitude characteristic of the condition, with the trunk bent slightly forward and toward the injured side. Respiration is shallow and rapid. The pectoral excursion on the injured side is usually less than that observed on the well side of the chest. Abnormal mobility is often present in the fractured rib near the site of the break. Crepitus may, or may not, be present accord-

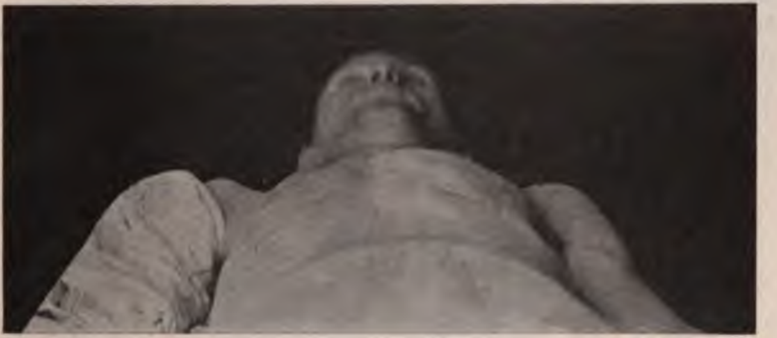

Fig. 542.—Caving in of chest with fracture of a number of ribs, the result of direct violence. Note the flattened condition of the chest on the patient's right side. Case seen with Dr. H. R. McGraw.

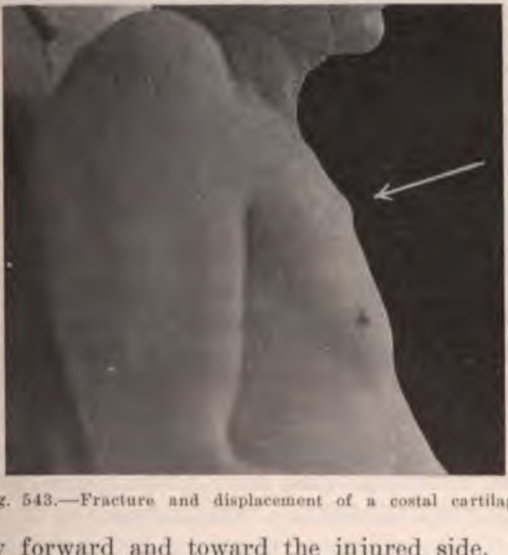

Fig. 543.—Fracture and displacement of a costal cartilage.

ing to the relation of the serrated ends of the fragments. Swelling of the parts is slight, if present at all. Ecchymosis may make its appearance within the first twenty-four to forty-eight hours following the accident. The lung may be penetrated by one of the fractured ends. Bloody expectoration and subcutaneous emphysema are the most common indications of this complication. In pronounced cases the subcutaneous tissues of the chest, face, neck and arms may be extensively distended with air. Palpation gives a distinct sense of crepitation when air exists within the tissues. Traumatic pneumonia may follow if the lung is injured.

Diagnosis.—The diagnosis is based on the symptoms just described, together with a careful and systematic examination of the chest. The ribs should be palpated in order, from above downward, for the purpose of recognizing crepitus and abnormal mobility. If pressure is made on a given rib, anteriorly (say the seventh), while the fingers of the opposite hand rest on the same rib in the posterior axillary line, the motion imparted to the rib, anteriorly, may be recognized by the opposite hand if the rib is intact between the points of palpation. If fracture is present, crepitus may be elicited in this manner, and dissolution of continuity appreciated when present. As previously stated the ribs possess a certain amount of spring, which quality should be tested when examining for fracture. If the chest be gently compressed antero-posteriorly pain will be produced or increased at the seat of fracture, which is promptly recognized and indicated by the patient. Crepitus, even with shallow respiration, may sometimes be determined by the stethoscope. Fractures of the posterior extremities of the ribs are not infrequently extremely difficult to diagnose because of their deep situation under the heavy muscles of the back. In such instances a radiogram will make the diagnosis possible.

Treatment.—Fixation of the injured side of the chest is the first indication in fractures of the ribs. This is best accomplished by strapping the chest with zinc oxide adhesive plaster. The usual method of applying the adhesive straps or swathe to the back first, and then encircling the chest during expiration is contrary to the principles of surgical anatomy in this region. The anterior portion of the chest is the movable part, while the spinal portion is fixed. The strapping therefore should be done from before backward (see Fig. 544). When the injured side of the thorax is fixed, relief from suffering is prompt and pronounced. The fact that the chest in respiration moves as a whole, renders it unnecessary to always apply the strapping directly over the rib fractured. If the lower portion of the chest is fixed on the affected side, relief will follow, even though the fracture be situated in one of the upper ribs. In other words, if the lower four or five ribs are fixed on the affected side motion in the entire half of the chest will be restricted. In severe fractures of the ribs, or in those presenting symptoms of pulmonary complications the strapping should not be applied too tightly, lest additional injury be done to the lung by forcing a displaced fragment or spicule into its substance. If suffering is not sufficiently relieved by strapping, the use of opiates may be necessary during the first day or two following the accident.

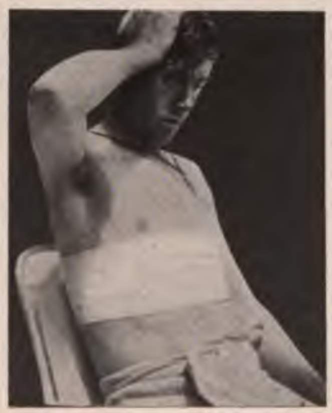

Fig. 544.—Adhesive plaster strapping for fracture of the ribs.

In fleshy persons, especially in women with pendulous breasts, fixation of the thorax is more difficult. The amount of subcutaneous tissue renders the skin more mobile and cutaneous irritation seems to be more readily produced, accordingly strapping is less satisfactory. In these cases a swathe snugly surrounding the lower chest will usually answer the purpose better than strapping.

Subcutaneous emphysema does not ordinarily call for special measures, yet should the condition become severe it may be relieved by multiple incisions.

After-Treatment.—The fixation dressing should be maintained for a period of about three weeks. In the milder cases in which a single rib is fractured, the patient may be up and about immediately following the injury. When the condition is more severe, as when a number of ribs are fractured, or the lung penetrated, treatment in recumbency is demanded. If respiration is painful or difficult in the dorsal position the patient may find comfort in turning on his side, or the backrest may be used to raise him to a semi sitting posture. It will often be necessary to tighten or reapply the strapping if it becomes loosened, or if cutaneous irritation develops. For these reasons the patient should be kept under close observation especially during the early part of the after-treatment. A linen swathe may be used about the chest if, for any reason, strapping seems inadvisable.

Prognosis.—Fractures of single ribs are almost invariably followed by complete restoration of function. Union with deformity is not likely to be followed by ill effects. The prognosis of severe crushing injuries, penetrations of the lung, traumatic pneumonia, etc., is that of the complication rather than of the fracture itself.

CHAPTER XXXIV.

FRACTURE-DISLOCATIONS OF THE SPINE.

Considerable useless distinction has been made between "fracture" and "dislocation" of the vertebræ. The use of the X-ray, of recent years, has demonstrated the fact that nearly all spinal fractures are complicated by at least some articular displacement, and that dislocations rarely occur without fracture of some portion of the vertebræ. This close association of the two conditions, therefore, renders the term "fracture-dislocation" the most satisfactory and accurate, and it will be understood in the subsequent discussion of injuries to the spine that one condition rarely occurs without the other. Dislocations, uncomplicated by fracture, are sometimes seen in the cervical spine but almost never in the lower portions of the column.

The importance of fractures and dislocations of the spinal column lies not so much in the bony injury sustained by the vertebræ, as in the damage which may be inflicted on the spinal cord contained within the spinal canal. In other words, the serious complications which follow fracture of the spine are shown by the symptoms of injury to the cord or spinal nerves rather than those of fracture of the spinal column. The diagnosis and treatment, therefore, come more properly under the head of neurology than of surgery. Since such is the case it will readily be seen that it is well for the surgeon, when possible, to have the counsel and coöperation of an experienced neurologist in dealing with fracture-dislocations of the spine.

Surgical Anatomy.—The character of the bony structure of the vertebræ is of importance in explaining the deformity which occurs in fracture-dislocations of the spine. The vertebral body is composed of a cancellous structure similar to that seen in the ends of the long bones. The surface is composed of a layer of compact tissue on which the strength of the body largely depends. In compression strains, little resistance remains after this bony capsule of compact tissue has been fractured; the internal cancellous tissue crushes readily and the body collapses. The vertebral arches, though less in bulk, are composed of a heavy compact tissue with a comparatively small amount of enclosed cancellated structure. The result is that fracture of this portion of the vertebra is more distinct and clean-cut in nature, with little or no loss of bone through crushing or impaction of cancellous tissue. The difference in the types of fracture occurring in these two portions of a vertebra may be likened to the difference existing between fracture taking place in the shaft, as compared to that seen in the expanded upper extremity of a long bone, such as the humerus.

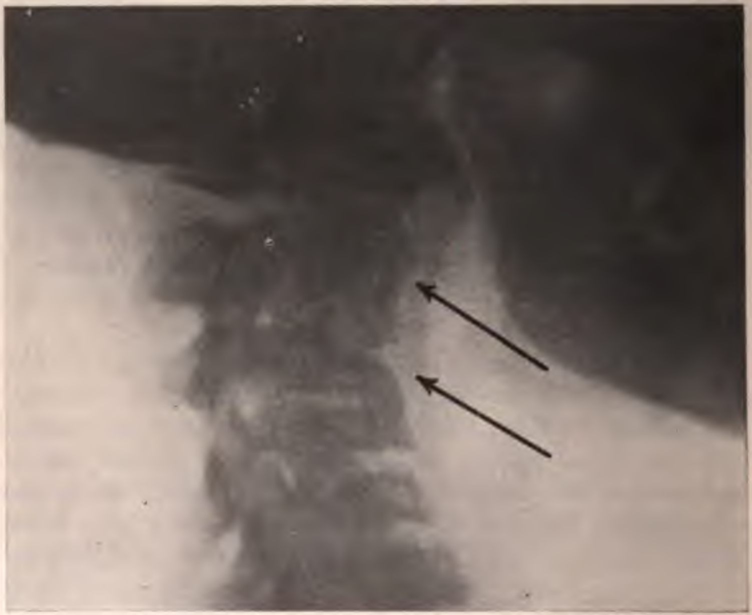

Fig. 545.—Fracture of the bodies of the second, third and fourth cervical vertebræ with kyphotic deformity.

The usual strain producing fracture of the spine is that of hyperflexion, and the effect upon the spinal column as a whole is similar to that occurring when other materials are subjected to bending strain. The convex side of the rod or column is under tension, the concave side under compression, while the intermediate part is in a neutral condition until either the convex or concave side of the column breaks. With hyperflexion, therefore, the bodies of the vertebræ are under compression while the vertebral arches and connecting ligaments are subjected to tension. In most instances the compression strength of the bodies is less than the tension strength of the posterior spinal ligaments. The usual result therefore, when the strain becomes greater than the spine can withstand, consists of a crushing of one or more of the vertebral bodies with kyphosis as a consequent deformity.

The planes of the articular surfaces in the cervical spine are more nearly parallel with the upper and lower surfaces of the bodies than in other portions of the spine. This less firm interlocking in the cervical region accounts to some extent for the comparative frequency of uncomplicated dislocations of the vertebræ in the neck. The upper portions of the spine normally carry less weight than the lower; hence the lighter structure in the cervical region. Accordingly the same degree of trauma will more surely produce fracture or dislocation in the neck than in other regions of the spine. As already explained the usual deformity is kyphotic; yet we may see angular displacements in other directions, and the deformity may be overriding or rotary, as well as angular.

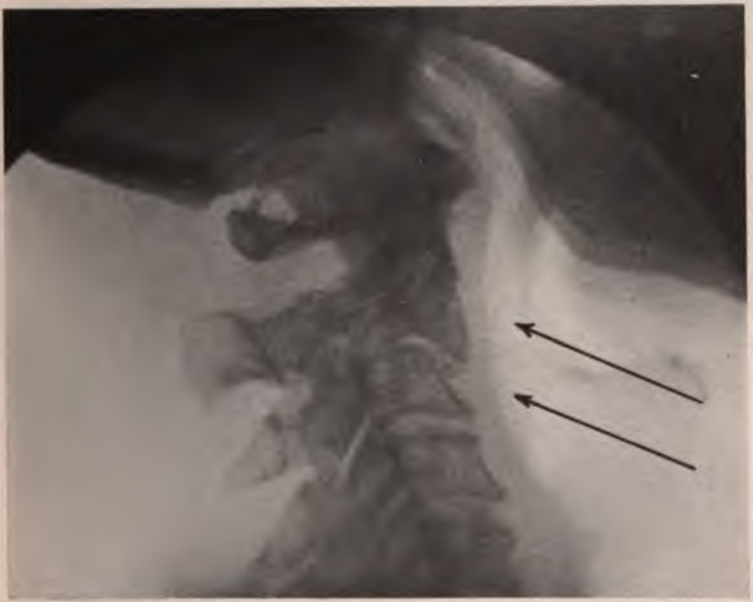

Fig. 546.—Fracture of body of second cervical vertebra with subluxation between bodies of second and third vertebræ. Fracture of second and third vertebræ near pedicles.

In Pott's disease the vertebral body gives way under normal strain as a result of diseased bony tissue; in fracture of the spine, with kyphosis, the normal body collapses because of excessive strain; the deformity is similar in both instances.

In the dorsal region, the articular surfaces change so they are more nearly at right angles with the articular planes between the bodies. This results in greater strength and lessened mobility, so that it is almost impossible to slide one vertebra on another (beyond ligamentous limits) without producing fracture. In the lumbar region the articular surfaces are also nearly at right angles with the articulations between the bodies although they correspond more closely with the sagittal than with the coronal plane.

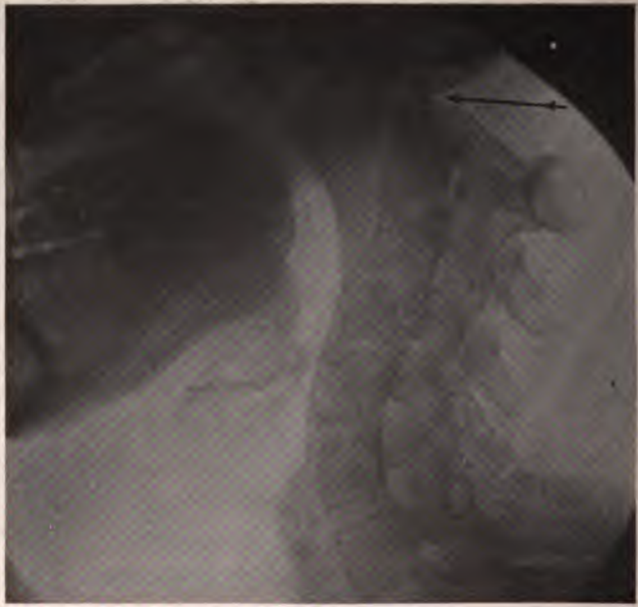

Fig. 547.—Dislocation between the first and second cervical vertebræ with forward displacement of the skull.

The tips of the vertebral spines are subcutaneous and palpable from the sixth or seventh cervical to about the fourth sacral. The anterior surfaces of the bodies of the upper four cervical may be palpated through the pharynx; the lumbar bodies through the anterior abdominal wall, in thin persons; and the coccyx and lower end of the sacrum through the rectum. Otherwise the heavy

Fig. 548.—Fracture of the lower dorsal and upper lumbar vertebræ with lateral deformity.

fasciæ and erector spinæ mass so conceal the deep portions of the vertebræ that it is impossible to accurately determine their condition and positions by palpation.

The spinal cord lies within the spinal canal, extending downward from the foramen magnum to about the level of the intervertebral disc between the first and second lumbar vertebræ. The level of the lower end of the cord varies somewhat in different persons. It is said to extend to a relatively lower level in women than in men, in short persons than in tall. This is explained by the growth of the individual. Early in fœtal life the cord occupies the entire spinal canal but the subsequent disproportion in growth between the spinal column and cord finds the conus terminal is on a level with the third lumbar vertebra at birth and later in life the cord terminates at the first or second lumbar according to the extent of longitudinal growth in the spinal column.

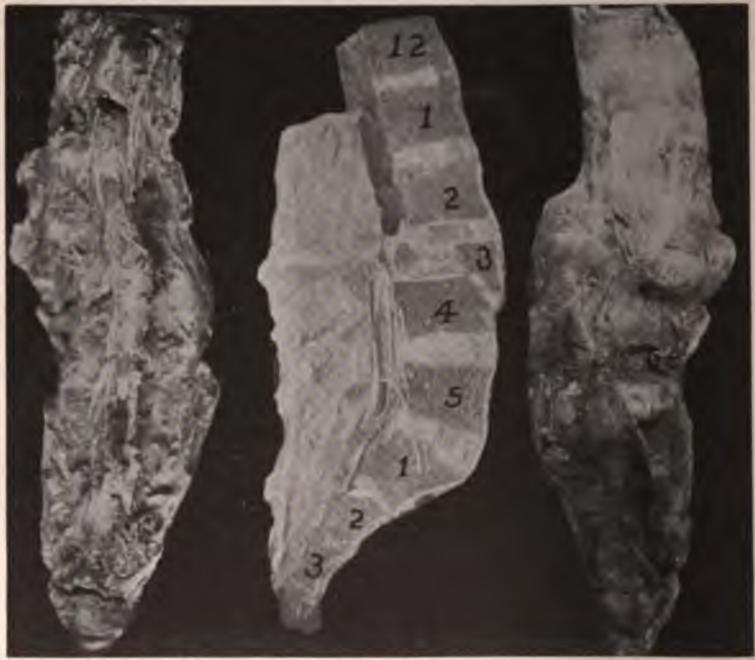

Fig. 549. Fig. 550. Fig. 551.

Figs. 549, 550 and 551.—Posterior view, sagittal section and anterior view of an old fracture of the spine. Note the constriction of the spinal canal and crushing of the cauda equina opposite the third lumbar vertebra.

In the early fœtal arrangement the spinal nerves arise from the

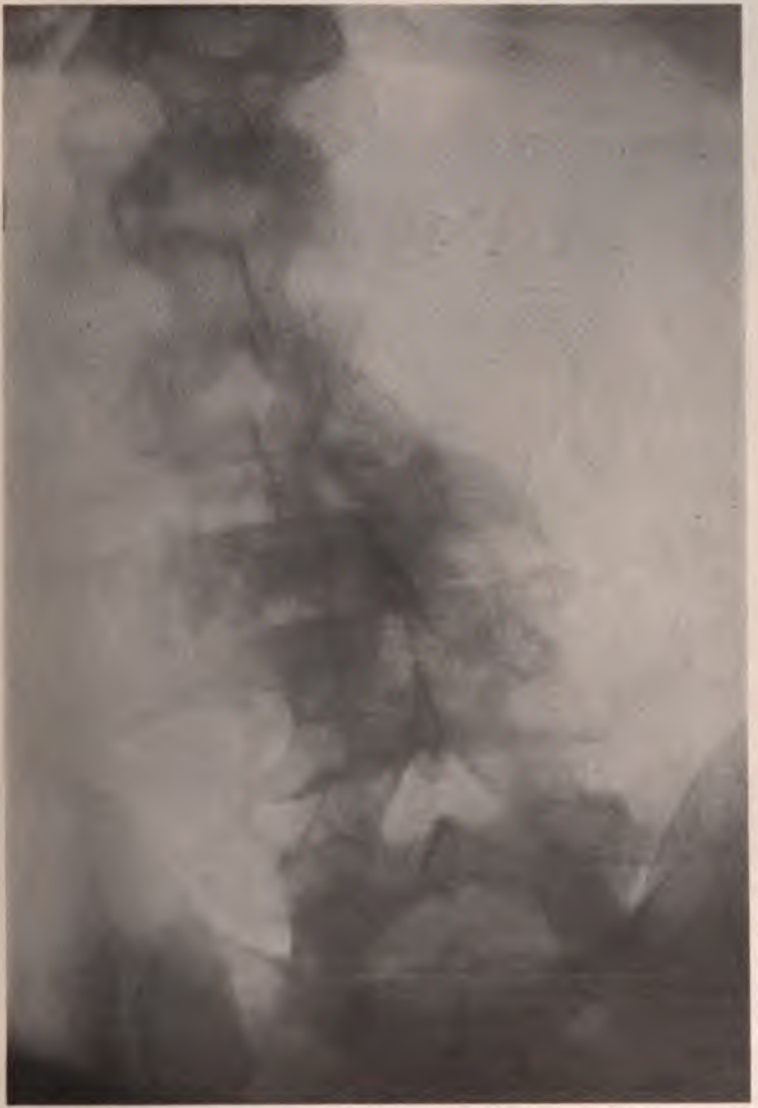

Fig. 552.—X-ray plate of case shown in Figs. 549, 550 and 551, some weeks before death.

cord opposite the intervertebral foramina through which they emerge. The fact, however, that the spine grows faster than the cord lowers the level of the spinal exit for a given nerve, with relation to its spinal cord origin. All of the spinal nerves, therefore, with the exception of the first two cervical, have a downward intraspinal course of greater or less extent, varying with the level of the nerve. The lower the nerve, the longer its intraspinal course.

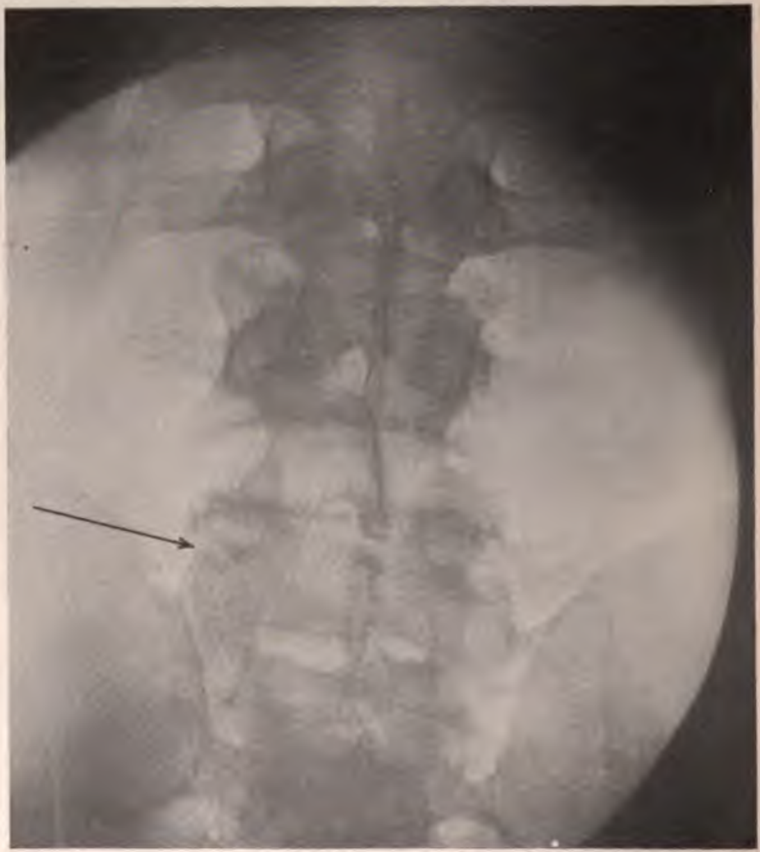

Fig. 553.—Fracture of the body of the fifth lumbar vertebra at the point indicated by arrow.

The spinal dura or "theca" forms a well, within the spinal canal extending from the foramen magnum to about the third sacral vertebra. The cord is suspended within this well and surrounded by cerebrospinal fluid in such a manner that injury by direct violence is almost impossible if the spinal column remains intact. The denticulate ligament and spinal nerves steady the cord within the theca and serve to prevent its coming in contact with the walls of the canal.

The tracts within the cord are composed of medullated aneurilemmatic axones, and when these fibres degenerate, following injury or disease, regeneration does not take place. Loss of function, therefore, is permanent. The spinal nerves, however, are both medullated and neurilemmatic and will regenerate under favorable conditions. This difference in structure and power of regeneration explains the invariable necessity for operative intervention to remove pressure in injuries of the cauda equina.

Symptoms.—The symptoms of fracture of the spine are, firstly, those of the bony lesion (the fracture itself) and secondly, those resulting from injury to the spinal cord or nerves.

The symptoms of fracture of the spinal column are:

1. Local pain and spasm.
2. Abnormal mobility.
3. Crepitus.
4. Deformity.
5. Loss of function.

The symptoms following injury to the cord and spinal nerves are:

6. Shock (and unconsciousness in cervical fracture).
7. Changes in pulse, temperature and respiration.
8. Motor disturbances.
9. Sensory disturbances.
10. Disturbances in reflexes.
11. Trophic changes.

SYMPTOMS OF FRACTURE OF THE SPINAL COLUMN.—

1. *Pain* is usually present at the seat of fracture, and is similar in character to pain produced by fracture elsewhere.[1] It is increased by motion and severe enough in some instances to produce syncope.

2. *Abnormal mobility* is usually present and can be recognized if the fracture has been at all severe. It is generally possible to

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[1] Reflex pain is not here considered.

flex the spine beyond normal limits, but the danger of producing or increasing injury to the spinal cord should preclude any and all unnecessary manipulations.

3. *Crepitus* may or may not be present but any attempt to elicit same, simply for diagnostic purposes, is absolutely to be condemned on account of the possibility of injury to the spinal cord or nerves.

4. *Deformity* varies with the region of the spine injured and the nature and degree of the fracture. It is almost invariably present. If the back be thoroughly inspected and carefully palpated the surgeon will, as a rule, experience little difficulty in recognizing the gravity of the condition even though the details of the fracture cannot be ascertained without resorting to the use of the X-ray. The usual deformity consists of anterior angular displacement of that portion of the spine above the fracture, with resultant kyphosis. In unusual instances the loss of vertebral alignment may be rotary. In severe cases overriding as well as angular deformity of the spinal column may occur. Kyphosis is often sufficiently pronounced to be recognized by inspection alone. It is seldom that the important elements cannot be determined by palpation. Fracture of one or more of the spinous processes with loss of alignment in the tips of the spines may produce a slight deformity which can

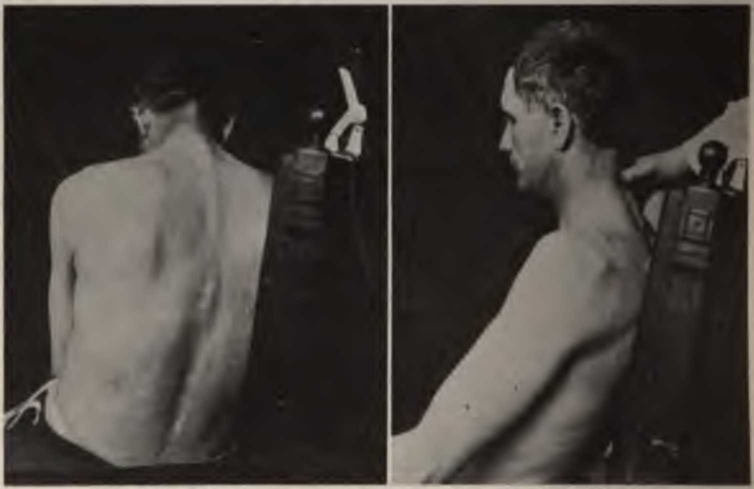

Fig. 554. Fig. 555.

Figs. 554 and 555.—Fracture of the spines of the third, fourth and fifth cervical vertebræ and of the bodies of the fifth and sixth. The thumb is depressed into the hollow caused by the displacement of the fractured spines.

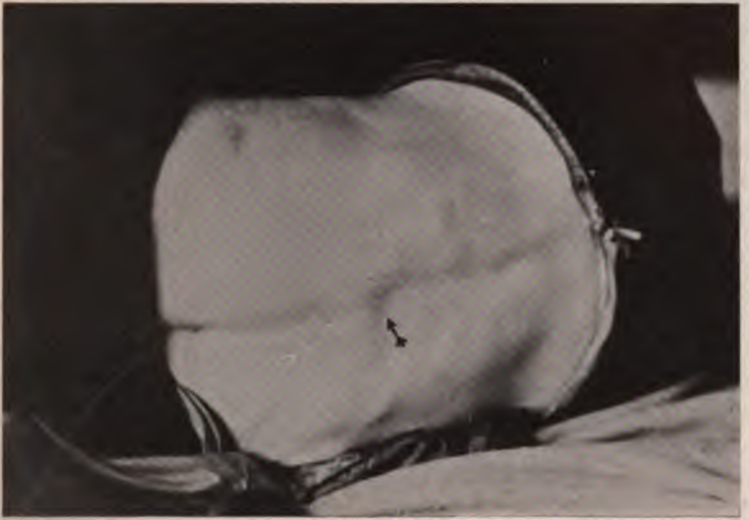

Fig. 556.

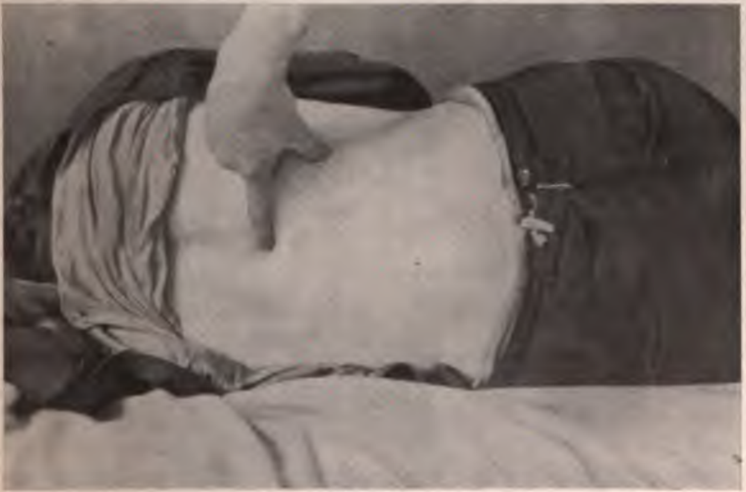

Fig. 557.

Figs. 556 and 557.—Fracture of the spine in the lower dorsal region a few minutes following the accident. Arrow in upper photograph indicates the visible irregularity in the spinous processes. In the lower plate (Fig. 557) the finger is pressed into the depression.

be recognized by palpation, if not by inspection alone. In isolated fracture of the spinous processes the deformity is slight and not accompanied by symptoms of fracture of the column itself, such as angulation of the spine, shock, motor and sensory disturbances, loss of function, etc. Fracture of the arches may be accompanied by symptoms of cord injury if the fragments have been displaced forward into the spinal canal.

5. *Loss of function* is inevitable in fracture of the spinal column, and will be more or less complete according to the severity of the injury. Shock, pain, and cord injury may disable the patient, but aside from these conditions the mechanical disturbances produced by the fracture are sufficient to prevent the patient from standing or sitting. Spasm of the muscles of the trunk, especially the erector spinæ mass, will be present, and represents Nature's attempt at splinting the injured parts. Loss of function through isolated fracture of the spinous processes, is mainly the result of local pain, especially when the muscles attached to the involved spine are brought into action. Local swelling and ecchymosis are seldom pronounced, if they occur at all. The extravasated blood and fluids of inflammation are so bound down by the heavy dorsal fascia covering the erector spinæ mass, that they seldom reach the surface.

SYMPTOMS FOLLOWING INJURY TO THE CORD AND SPINAL NERVES.—The symptoms following injury to the spinal cord or the nerves contained within the spinal canal vary with the completeness and region of the injury. The nature and degree of these symptoms are explained by reverting to the anatomy of the spinal cord and the distribution of the spinal nerves. Slight pressure on the spinal cord, such as produced by hemorrhage (and in some instances slight bony displacement), is prone to produce irritation of the spinal centers which, if allowed to continue, is not uncommonly followed by a degeneration of the affected cells and their axones. Destruction of spinal cord tissue is invariably accompanied by prompt loss of function in the destroyed cells, and interruption of impulses in the damaged white tissue of the cord. If the damage to these cells has been at all severe, degeneration ensues regardless of relief of pressure. If, however, pressure is not removed pressure myelitis is almost sure to follow, the degenerative process will be more extensive, and adjoining cells and tracts will be involved, which were primarily unaffected at the

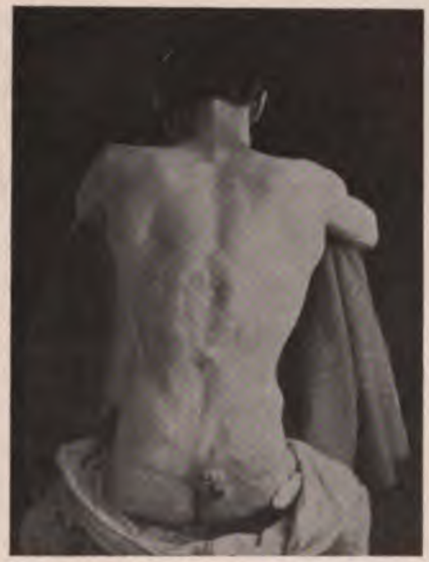

Fig. 558.—Fracture of the lower dorsal spine some eight years following the injury. The cord was partially crushed and paralysis of the lower extremities with loss of bladder and bowel control followed. Note the chronic sore in the sacral region and the cord about the hips supporting a urinal.

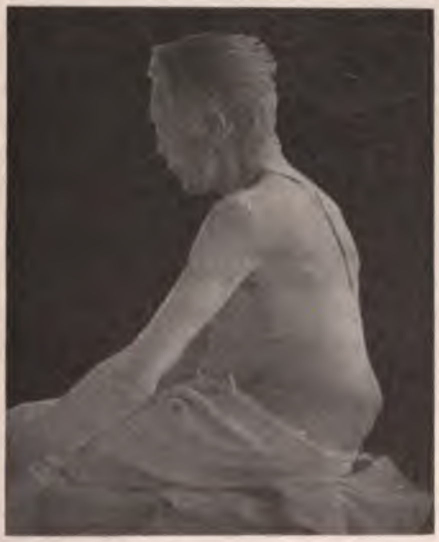

Fig. 559.—A case of Charcot's spine showing the same type of kyphotic deformity as is sometimes seen in fractures of the lumbar spine. Paralysis of the lower extremities and loss of sphincteric control due to pressure on the spinal nerves within the canal.

tion of injury. There are none of the so-called silent areas within the cord such as those existing in the brain, and hence lesions of the cord, whether partial or complete, are always attended by disturbances in function.

6. *Shock*, at least in a mild degree, accompanies all uncomplicated fractures of the spine and is greatly augmented when the cord is injured. Unconsciousness, however, rarely occurs unless the injury is in the region of the upper four cervical vertebræ.

7. Except in injuries of the upper cervical region pronounced *changes in temperature, respiration and pulse* do not occur immediately following the accident. Shock may influence the temperature, pulse and respiration, but shock may occur in many conditions and is not characteristic of cord lesions. Later in the course of the case pressure myelitis, meningeal complications or degenerative processes within the cord may cause a rise of temperature, with alterations in the pulse and respiration.

8. *Motor disturbances* at and below the seat of fracture, are the rule when the cord is injured and the character of these symptoms varies according to the nature, region and completeness of the lesion. In complete crushing of the cord paralysis will be found in the parts supplied by the damaged segments, and all the segments below them will be thrown out of function. In partial injuries of the cord the musculature supplied by the injured segments [illegible] more or less complete flaccid paralysis, while the muscles [illegible] lower segments will be spastic. The condition of the [illegible] is difficult to recognize immediately following [illegible] of the accompanying shock and temporary [illegible]

[illegible] is simple and regular. [illegible] the level of the spinal [illegible]. When, however, [illegible] spinal segments [illegible] nervous formations [illegible] segments [illegible] of the additional nerve supply which it receives from the sympathetic system. Disturbances in the control of the bladder and bowel will be considered under injuries of the lumbar enlargement. The motor areas of the cord are more easily injured than the sensory, and hence in partial lesions motor paralysis is often more extensive and complete than are the sensory disturbances. The symptoms of cord injury following bony displacement are almost always paralytic from the first and are not progressive in nature. But on the other hand, hemorrhage within or about the cord is often accompanied by irritative symptoms, such as spasm or tremor, and the intensity of these symptoms usually increases both in degree and extent. Hematomyelia (hemorrhage into the substance of the cord) and hematorrhachis (hemorrhage about the cord) are not uncommon complications of spinal cord injury. It is a peculiar fact that crushing injuries of the cord are frequently followed by hemorrhage into its substance a few segments above the site of the lesion. When this secondary traumatic hematomyelia above the lesion occurs, it usually develops within the first few days. Hematorrhachis is more properly a complication than a sequel, since its onset is prompt following injury to the spinal plexus of veins at the seat of injury. In either of these conditions the symptoms are, as a rule, progressive. The motor and sensory losses are not infrequently preceded by evidences of irritation in the spinal centers. In rare instances slight pressure upon the cord from bony displacement may produce symptoms simulating hemorrhage, provided the pressure is not sufficiently pronounced to produce immediate destruction of cord tissue. Under these conditions the symptoms may be irritative and occasionally slightly progressive.

9. *Sensory disturbances* are common in cases of spinal cord injury, though in partial lesions they are usually less pronounced and extensive than are the motor symptoms. In complete transverse cord injuries anesthesia develops immediately in the areas supplied by the injured portion of the cord, and in addition the sensory function of all segments below the lesion is promptly, completely and permanently lost. This area of anesthesia is soon followed by a girdle of hyperesthesia representing two or three spinal segments directly above the injured region of the cord. This area of hyperesthesia is the result of irritation of the spinal centers contained within the segments adjoining the lesion, and may be the only evidence of a hematomyelia which so commonly

develops in the cord tissue near the injury. Great suffering sometimes occurs as the result of reflex shooting pains throughout the hyperesthetic area. This condition in the thoracic portion of the cord produces girdle pains; in the lumbar enlargement, shooting pains in the lower extremities and genetalia; while spinal irritation in the upper dorsal or lower cervical segments of the cord may produce pain in the upper extremities. Hyperesthesias following irritation of spinal centers will vary in degree and distribution according to the region and severity of the cord lesion.

10. *Disturbances in reflexes.*—In complete cord lesions the reflexes below the injury will be immediately, completely and permanently abolished. Shock, from any cause, may produce temporary loss of reflexes which return, however, as the patient recovers. Accordingly too much stress should not be laid on their absence immediately following the accident. In partial lesions the reflexes, dependent upon the damaged segments, will be lost or reduced, while those below the lesion are often absent immediately following the accident, though they return later and are often increased through lack of inhibition from the higher centers. When such is the case patellar and ankle clonus are present, together with Babinski's reflex, and other pathologic reflexes of the foot and ankle, indicating damage to the upper motor segment. The loss of reflex activity is often asymmetrical in partial lesions, and corresponds more or less accurately to the distribution of motor and sensory losses. If the reflex of a given segment is increased through spinal irritation, spasm, tremor or hyperesthesia will probably be present in the corresponding area.

11. The *trophic disturbances* following injury to the cord are among the most serious and difficult to control of the complications with which we have to contend. Most prominent among them are the bed sores which develop where continued pressure is applied to subcutaneous bony prominences, especially in the region of the sacrum and heels. The sacral sores are often intractable, rapidly attaining such size and depth as to lay bare the lumbar and sacral vertebræ, and not infrequently a considerable part of the ossa innominata. When this type of sore develops the patient usually succumbs within a short time, either from exhaustion and a general septic condition or following involvement of the exposed spinal membranes. The musculature below the seat of injury atrophies until in extreme cases the outlines of the bones of the lower ex-

tremities are apparent on inspection. Contractures are common, especially in the feet, which are often depressed and in a condition resembling that seen in hydrocephalus. The bladder changes are due partly to the effects of retention following paralysis, and partly to the disturbed trophic supply of the viscus. Infection of the bladder, with urinary decomposition, develops sooner or later in spite of the most assiduous care. This infection not infrequently ascends to the kidneys, ultimately producing death.

The symptoms accompanying fracture-dislocations of the spine show such variation in different levels that for practical purposes we will consider the symptoms peculiar to the different regions.

Fracture-dislocations of the cervical spine are often immediately fatal, especially when the injury involves the upper four vertebræ. Dislocations uncomplicated by fracture are more common here than in other portions of the spinal column (see "Anatomy," page 465). The usual deformity is kyphotic, though the displacement may, in unusual instances, be lateral, posterior, rotary or even overriding. Unilateral luxations are more common in the neck than in other portions of the spine, their usual seat being in the occipito-atlantal or in the atlo-axial articulations. If death does not follow the injury within a few hours motor and sensory disturbances develop in the regions supplied by the injured spinal segments and below the site of the lesion. Injuries at, or above, the fourth spinal segment destroy or interfere with the nerve supply to the diaphragm, and the proximity of the important centers in the bulb, together with the close association between the pneumogastric and spinal-accessory nerves, renders fractures in this region especially dangerous. When death is not immediate pronounced variations are usually observed in the temperature, pulse and respiration. The temperature may rise to 105° or 106° or even higher, the pulse becoming rapid and arythmic. The more complete the loss of function in the phrenic, the more pronounced will be the action of the accessory muscles of respiration provided they are still capable of action. Fracture of the cervical region may involve the segments from which the nerves of the brachial are derived, and the muscles paralyzed in the upper extremity will vary according to the level of the lesion. When the lesion involves the upper portion of the brachial plexus the upper extremities will be held in a characteristic position with the elbows flexed, and the upper arm abducted and rotated outward. Injury to the lower portion of the plexus produces a different attitude, with the arms not far from the side and the hands resting on the chest in pronation. The reason for these differences in attitude is explained by the formation and distribution of the brachial plexus. In complete lesions of the cervical cord death almost invariably occurs within a few hours, if not at the time of the accident. If the patient survives the immediate effects of the injury the usual motor and sensory paralyses develop below the site of the injury, including loss of sphincteric control. If he lives a few weeks trophic disturbances make their appearances, the most important of which is the bed sore.

Fracture-dislocations of the thoracic region are more constant in their type of deformity than are corresponding injuries in either the cervical or lumbar spines. Kyphosis with crushing of the body of the vertebra is the rule. Fractures of the upper thoracic region do not commonly influence motion or sensation of the upper extremities, though the usual symptoms develop below the lesion according to the severity of cord injury. Loss of sphincteric control with sensory and motor disturbances of the legs and lower trunk are present. Diminished or lost peristalsis sometimes results in severe tympanites and fecal impaction, through interference with the nerve supply of the intestines. Any or all of the abdominal viscera may show diminished function. The thoracic portion of the spinal cord extends from the level of the sixth cervical interspace to the ninth thoracic vertebra, and hence fractures of the spine below this level involve the lumbar enlargement or the cauda equina rather than the dorsal segments.

Injury to the lumbar enlargement, situated opposite the lower three thoracic and first lumbar vertebræ, gives rise to flaccid paralyses of the lower extremities, varying in degree with the severity of the lesion. The centers controlling the bladder, bowel and genitalia are all situated in this portion of the cord, and hence disturbances in function occur in these parts when this portion of the cord is injured.

Injuries below the first lumbar vertebra may damage the nerves forming the cauda equina; the motor and sensory losses will vary according to the nerves injured. The reflexes in the lower extremities will be lost if the nerves are crushed. Shock will be much less than that accompanying injury to the cord itself even when all the nerves are crushed.

Diagnosis.—The diagnosis of fracture of the spine and its complications, is based on the symptoms previously described. The alignment of the spine should be determined by inspection, and the tips of the spinous processes carefully palpated. Isolated fractures of the spines produce only local pain, abnormal mobility, and sometimes crepitus; the symptoms of fracture of the spine as a whole are absent. It is, as a rule, an easy matter to determine the presence of fracture in the spinal column, although an accurate appreciation of the details of the fracture is often only had by means of the X-ray or at autopsy. Unless the most careful examination is made in fractures without deformity the condition may be overlooked and subsequent displacement may produce injury to the cord which could have been prevented if proper fixation apparatus had been employed. The important element in fracture of the spine is that of cord injury, the degree and position of which determine the treatment. Complete transverse lesions produce immediate, total, permanent and symmetrical loss of motion, sensation and reflexes below the lesion. Partial lesions are usually followed by irregular, incomplete and asymmetrical motor, sensory and reflex losses. The motor losses below the lesion are spastic, while the paralyses in the muscles supplied by the injured segments are flaccid. In complete lesions the motor losses, at and below the lesion, are all flaccid. In cord injuries, loss of motion in a single muscle, or group of muscles, never occurs. Such a condition means injury to one of the peripheral nerves rather than a spinal segment or nerve root. When a spinal nerve is crushed in one of the intervertebral foramina, the motor and sensory losses are confined to the distribution of that single nerve root. The loss of reflexes, accompanying shock and unconsciousness, often prevents the surgeon from making an early diagnosis. The degenerative and inflammatory changes within the cord, following pressure, may begin within a few hours of the injury, and hence the value of an early diagnosis is apparent. The symptoms of bony pressure are prompt in onset, and usually not progressive, while pressure due to hemorrhage produces symptoms which increase in severity as the blood escapes into or about the cord. Pressure myelitis, however, gives rise to symptoms which are practically identical with those of hemorrhage, and in a given case it is not infrequently impossible to differentiate between the two. It is, also, extremely difficult in some instances to differentiate between a partial lesion due to bony pressure and that due to hemorrhage.

The difficulties of diagnoses in these cases are greatly increased by the manner in which shock and unconsciousness sometimes obscure the symptoms for a number of hours following the injury. Symptoms simulating complete lesions frequently change within the first twenty-four hours, being replaced by the symptom-complex of a partial injury. The X-ray, especially in stereoscopic form, is sometimes of the greatest service in determining the extent to which the lumen of the spinal canal has been encroached upon by bony displacement. The level of the cord lesion is determined by the level of the motor and sensory disturbances, particularly the level of the hyperesthetic zone and the area of flaccid paralysis.

Treatment.—The treatment of fractures of the spine is directed, firstly, towards the fixation of the injured portion of the column, and secondly, to the alleviation of complications and their symptoms. With the exception of isolated fractures of the spinous or transverse processes fracture of the spinal column calls for a fixation in some form regardless of whether or not the cord has been injured. Fixation is most satisfactorily accomplished by means of a plaster cast, modified according to the region of the injury. In the cervical spine it should be so applied as to include the head, neck and shoulders, leaving the arms free. In the dorsal region, it will be necessary to include the chest and upper abdomen, together with the neck, if the fracture is high. When the lower dorsal or lumbar vertebræ are fractured the cast should extend from below the armpits to the hips, including the crests of the ilia. In whatever region the cast is applied, the deformity should be previously corrected as perfectly as possible, and the patient's position maintained unchanged until the plaster has become sufficiently set to properly splint the parts.

Fractures of the cervical spine may be held in reduction by the hands of an assistant while the cast is being applied. In the dorsal and lumbar regions, correction of the deformity is much more difficult because of the weight and bulk of the parts handled. Reduction in these portions of the column may be accomplished in a number of ways, any of which is satisfactory if properly performed. The possibility of producing cord or nerve injury, or even death, while correcting the deformity should be constantly kept in mind during these procedures. All manipulations should be gradual, gentle, and guarded and the greatest care exercised in moving the patient to avoid strain or further displacement of the injured portions of the spine.

If the patient is placed on two tables, face downward, and the tables so separated that the body sags downward between them, the deformity will not uncommonly be reduced without further manipulation. Gentle pressure over the prominent spines may be necessary in addition to secure proper relations of the fragments. Two or three assistants will be necessary to securely hold the patient at the shoulders and heels to prevent his slipping off the tables, and to maintain the proper degree of spinal curvature. In this position the surgeon may begin the application of the plaster bandages, the skin of the trunk having been previously protected by means of a snug, soft woven shirt. Another method consists in suspending the patient in a hammock, and so regulating the tension at which the hammock is hung that the proper spinal curvature is obtained, and the deformity corrected. The Bradford-Lovett hammock frame is an excellent apparatus in the application of a cast of this kind. It matters little how the cast is applied provided the following essentials are observed: The deformity should be corrected; the cast should be sufficiently heavy to withstand the subsequent strain; it should possess some non-irritating lining and should so secure the trunk that the spine is immobilized. A stomach pad consisting of two or three folded towels should be placed over the abdomen, before the plaster is applied and removed when the cast is completed. This allows room for comfortable respiration and eating during the after-treatment. It is essential that the cast remain exposed to the air (not covered with bed clothes) for twenty-four hours, or until the plaster has thoroughly set and dried.

Immobilization of the spine may be accomplished in other ways besides the plaster cast, though probably not any more satisfactorily in the usual case. Steel braces, similar to those employed in the treatment of Pott's disease, may be used in fixing the spine.

The water bed has been much used in the treatment of these cases, though the fixation of recumbency alone is by no means as efficient as that produced by the cast or brace. In the early treatment of fracture of the spine, extension and counter-extension may be employed by means of Buck's apparatus applied to both legs with the foot of the bed raised. Sand bags about the body serve to steady the parts, and a small, hard pillow under the small of the back will maintain the proper dorsal curvature. The Bradford frame may be used to advantage when simple recumbency is the method of fixation.

If the fracture is complicated by cord or nerve injury, the indications to be met in the treatment are much more complex. In addition to fixation of the spine, the relief of symptoms resulting from the complication is demanded as far as may be possible. This may, or may not, require operation. When an absolute diagnosis of complete crushing to the cord can be made, operation is contraindicated, since it can do no good. In partial lesions we should open the spinal canal at the seat of injury for the removal of such pressure as may be present. Fractures of the spine below the cord, with symptoms of injury to the cauda equina, call for operation.

Operative Treatment.—The question of when to operate and when to treat the patient expectantly has been the subject of much discussion. At the present time, however, it is commonly agreed by most surgeons that complete crushing injury to the cord should not be operated because of the hopelessness of the condition. The difficulty in determining when, and when not, to operate in a given case arises from the difficulty of an accurate diagnosis of the condition of the cord. Partial lesions to the cord and injuries to the cauda equina demand operative intervention in almost all cases. The peculiarities of each individual case, however, must be considered by themselves, and complicating conditions such as shock and injuries to other portions of the body, especially the skull, necessarily modify the indications for operation and the best time for its performance. Compound fractures of the spine invariably call for surgical measures. The objects for which operation is performed, are: the correction of deformity, decompression of the cord, suture of nerves, and the treatment of the wound in compound cases.

The permanency of the sensory and motor losses determines the completeness of the cord injury, but when operation is delayed for a few days to establish the diagnosis, the prognosis in partial lesions is rendered much worse by the development of pressure myelitis, and other degenerative processes within the cord. For this reason some surgeons maintain that the spinal canal should be opened in practically all instances complicated by cord injury, for the sake of removing pressure in partial lesions which could not be otherwise differentiated from total crushes. If we follow this principle, we must, of necessity, submit many cases of complete crushing to operation for the sake of relieving pressure in instances in which the lesion proves to be only partial. The question might then be asked, and not without reason, "What harm has been done by operating upon complete lesions when they are hopeless from the first?" Spinal decompression is by no means as successful as might be wished, yet if only a moderate degree of improvement results the operation is justified. The state of the patient, even though he be confined to a wheel chair is much more tolerable than when he is completely bedridden and unable to help himself.

The spinal canal may be opened by simple laminectomy, or by means of an osteoplastic resection. In performing a laminectomy, a median incision four or five inches long is made in the region of the injury. The muscles are separated from the spines and laminæ on either side, preferably by blunt dissection. If hemorrhage proves troublesome one side should be packed with gauze, while the other is being worked upon. It is next determined how many sets of spines and laminæ are to be removed to properly expose the region of injury. The supra- and inter-spinus ligaments and ligamentum subflavum are then divided below the lowest spine to be removed and above the uppermost pair of laminæ to be included in the resection. Care should be taken not to introduce the scalpel too far in dividing the ligaments lest injury be inflicted on the contents of the neural canal. The laminæ are next divided near their junction with the transverse processes by means of a saw, chisel or heavy bone cutting forceps, after which the osteo-ligamentous section is removed, exposing the dura. The theca is then opened by immediate incision, and the cord and its nerves examined. Inspection and palpation will disclose the nature and degree of pressure on the cord, together with the secondary changes which may have occurred. Pressure may be relieved in some instances, by simply correcting the deformity in the column, or it may necessitate the chiseling away of bony prominences or the removal of fragments. Hemorrhage about the cord is readily recognized when the dura is exposed and opened. Hemorrhage into the substance of the cord gives a distended, swollen appearance. It is probably wise to drain the contents of hematomyelia, though this procedure has not been performed sufficiently often to permit of trustworthy conclusions. The removal of spines and laminæ leaves a deficiency in the spinal column, yet disturbances in function resulting from this loss are extremely rare. Laminectomy produces greater injury to the circulation than occurs in an osteoplastic resection, yet it has other advantages which more than make up for the difference. When the normal anatomic relations are disturbed by fracture or dislocation, it is safer to expose the laminæ before dividing them; there is less danger of injury to the contents of the canal if the bony landmarks are exposed and the deformity accompanying the fracture fully appreciated.

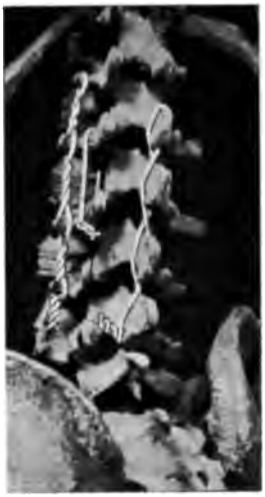

Fig. 560. Methods of wiring the processes together sometimes employed in operating on fractures of the spine.

In opening the spinal canal by the osteoplastic method a U-shaped incision is made, the vertical arms of which are parallel to the spinous processes in the region of the injury. The soft tissues are divided by a deep incision, down to the laminæ. The ligaments are then divided transversely between two vertebræ below the seat of the fracture as described in laminectomy. The laminæ are then cut on either side near their junction with the pedicles, a sufficient number of arches being divided to turn four or five spines upward in the osteoplastic flap. When this operation is done in the dorsal region, where the spines are imbricated, it may be necessary to remove the tip of the vertebral spine just above the base of the flap before the latter can be turned back. This is best accomplished through a short, median incision over the spine to be removed (see Fig. 561). After the deformity has been corrected, and the pressure, whether due to bone or blood, removed, the flap is sutured in position, with drainage in the lower angle. It is usually necessary to apply a cast to maintain reduction.

When injuries to the cord exist nothing can be done which will be followed by regeneration in the destroyed cells or tracts, yet deformity should be corrected and pressure removed to avoid the subsequent development of secondary complications. If spinal nerves are divided they call for suture, in addition to the removal of pressure.

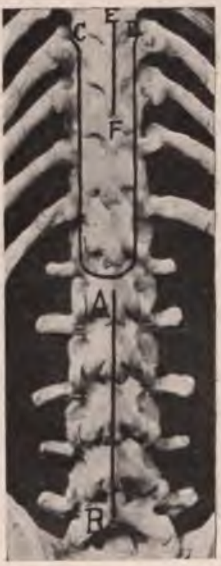

Fig. 561.—Lines indicating the incisions used in operations on the spine. *A.-B.*, median incision employed in laminectomy. The loop *C.-D.* is used in an osteoplastic flap. The incision *E.-F.* is made to divide the spinous process above the flap so the flap may be turned back.

There is no established technique or mode of procedure in operating upon fractures of the spine. The findings in a given case will point out the indications. The operations just described are for the purposes of relieving cord and nerve injuries, and have little to do, primarily, with the correction and fixation of the deformity. Operation for these purposes alone is only rarely found necessary. If an uncomplicated fracture of the spine exists, with pronounced tendency to the recurrence of deformity following reduction, we may be justified in exposing the spines and laminæ with a view to fixing them by means of wire as described by Hadra. The essentials of the method consist in securing sound spines above the injury to those below the seat of fracture, by means of silver wire (see Fig. 560).

After-Treatment.—The after-treatment in fractures of the spine is directed firstly, to maintaining fixation of the fracture, and secondly, to the symptomatic treatment of disturbances resulting from cord or nerve injury. The apparatus used for fixing the spine whether cast, brace, extension or other apparatus, should be carefully inspected from day to day to avoid irritation of the soft parts which so often results in the development of sluggish sores. This applies to any form of fixation appliance employed in the treatment of fracture, but especially in complicated fractures of the spine when anesthesia and the loss of the protective pain sense, together with disturbed trophic supply favors the development of sores and extensive sloughs without the patient realizing his condition. The buttocks and heels require especial care to prevent the development of bed sores. A pneumatic ring may be used to relieve the sacral region from pressure, and pads of cotton may be placed under the tendo-achillis to prevent the heel resting on the bed. These parts, especially, should be bathed in alcohol twice daily if the slightest evidence of skin irritation is present. The perineal and gluteal regions should be kept scrupulously clean to prevent irritation from urine and feces.

One of the most discouraging conditions with which we have to contend is that of cystitis which almost invariably develops following the repeated use of the catheter. It is needless to say that the most strict aseptic precautions should be observed if catheterization is found necessary. It is advisable, when possible, to rely on the bladder's emptying itself, even when a moderate degree of urinary distention is present. Gentle massage of the distended viscus will often result in a fairly satisfactory evacuation of the bladder, and although this method is by no means ideal, yet it is far better to get along in this way than to resort to the catheter with its almost inevitable train of disastrous results following infection of the genito-urinary tract. If the bladder becomes infected during the after-treatment, it is often best to establish permanent drainage to control the condition. Suprapubic cystotomy may be performed and a suction apparatus employed to keep the bladder empty. This is probably as satisfactory a method as any of dealing with infection of the bladder under these circumstances. When analgesia is present in the hypogastric region, the operation may be performed without an anesthetic. The bladder should be washed at least once daily with a boric acid or potassium permanganate solution. Some surgeons prefer perineal drainage. Permanent catheterization has been employed with success, though the urethra will not tolerate the presence of a foreign body indefinitely. The intermittent use of hexamethylenetetramine will be found of service in dealing with infection of the genito-urinary tract.

Obstipation and fecal impaction sometimes accompany fracture of the spine, and must be dealt with by laxatives, enemata, massage, and in some instances mechanical removal of the impacted material.

The condition of some of these patients is so obviously hopeless that it is often wise to make them comfortable even though, in some respects, it may be at the expense of their physical welfare. Severe shooting pains in the hyperesthetic areas, when severe, call for the exhibition of opiates.

Prognosis.—The outlook in uncomplicated fractures of the spine is good, especially when a fair reduction of the deformity has been accomplished. When, however, injuries to the spinal cord accompany the fracture, the prognosis is, at best, discouraging. There will be permanent loss of function, the degree varying with the extent of the injury, and the improvement which takes place in these cases is usually too trifling to be of real importance. Cases of partial injuries to the cord which survive the immediate effects of the accident, lead a life of invalidism varying from a few months to a few years. Cases of complete crushing of the cord seldom live more than a few months. Death usually follows as a result of some intercurrent condition, such as infection of the genito-urinary tract, meningitis, septic states, pneumonia, etc. The lower the injury in the spine, the better the prognosis. Operation is of no avail in complete crushing injuries, although it renders the prognosis much more favorable in partial lesions especially when done within a few hours of the injury.

CHAPTER XXXV.

FRACTURES AND DISLOCATIONS OF THE PELVIS.

Surgical Anatomy.—The pelvis is originally made up of fifteen bones; three in either os innominatum, five in the sacrum and four in the coccyx. When ossification is complete we have but four, including the coccyx which is attached to the lower end of the sacrum. The pelvis has fifty-five centers of ossification, some of which are of surgical importance. The os innominatum has three primary centers, one for each of the three bones entering into its formation. The ilium, ischium and pubis meet in the acetabulum, and prior to the fusion of these three bones they are separated by a Y-shaped cartilage. A blow on the trochanter therefore, may break the os innominatum into its three anatomical parts, the injury resembling the epiphyseal separations seen elsewhere in the long bones. The three bones become united at about the seventeenth year, after which this injury cannot take place. The entire

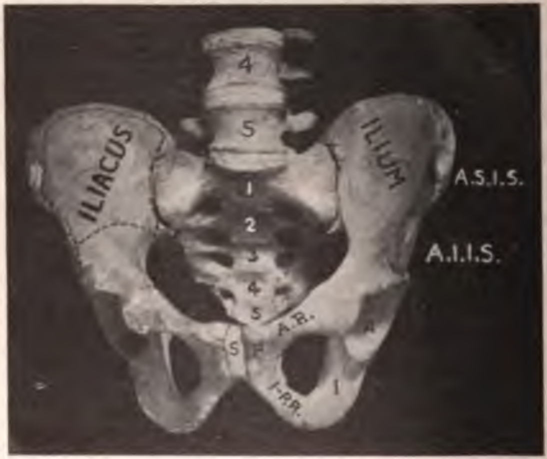

Fig. 562.—The pelvis. *S.*, Symphysis pubis; *P.*, Body of pubis; *A.R.*, Ascending ramus; *I.-P.R.*, Ischio-pubic rami; *I.*, Ischium; *A.* Acetabulum; *A.S.I.S.*, Anterior-superior iliac spine; *A.I.I.S.*, Anterior-inferior iliac spine. Lumbar and sacral vertebræ numbered in order.

crest of the ilium may be separated as an epiphysis, or its anterior portion may be pulled away by muscular action prior to the twenty-fourth year, at which time it joins the rest of the ilium. The epiphysis of the anterior inferior iliac spine has been avulsed by the action of the straight head of the rectus femoris, and by traction transmitted to it through the Y-ligament of Bigelow. The development of the sacrum is also of interest in this respect; the lateral surfaces of the bone are ossified by plates which are in reality epiphyses. Fracture in this region will find the plane of least resistance, often following the epiphyseal cartilages rather than the articulation itself. Fracture of the incompletely ossified sacrum follows the cartilage rather than the bone.

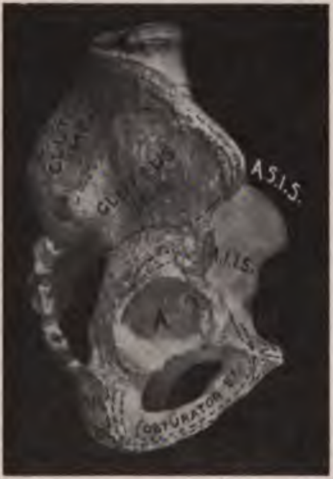

Fig. 563.—Lateral view of pelvis. *A.S.I.S.*, Anterior-superior iliac spine; *A.I.I.S.*, Anterior-inferior iliac spine; *G.M.*, Gluteus Maximus; *G.Med.*, Gluteus medius; *Gluteus min.*, Gluteus minimus; *A.*, Acetabulum; *S.M.*, Semimembranosus; *B.*, Biceps.

The ossa innominata transmit the weight of the body from the spine to the femora in the erect posture, or to the tubera ischiorum in the sitting position. The sacrum, together with that portion of the ossa innominata behind the acetabula, forms an arch for the transmission of weight to the femora; another arch with the tubera ischiorum as the base transmits the weight from the spine to the object on which the person sits. The anterior portion of the pelvis is composed of the pubes, and the rami which connect them above and below the thyroid foramina with the remainder of the pelvis. This part of the pelvis is composed of two counter-arches for the support of the two main arches just described. The pubes and two ascending rami constitute the upper counter-arch, reënforcing the main arch which transmits the weight to the femora; while the pubes and two ischiopubic rami form the counter-arch for the main arch having its base in the two tubera ischiorum. The anterior portion of the pelvis is much lighter than the posterior and more frequently fractured. The main arches are very

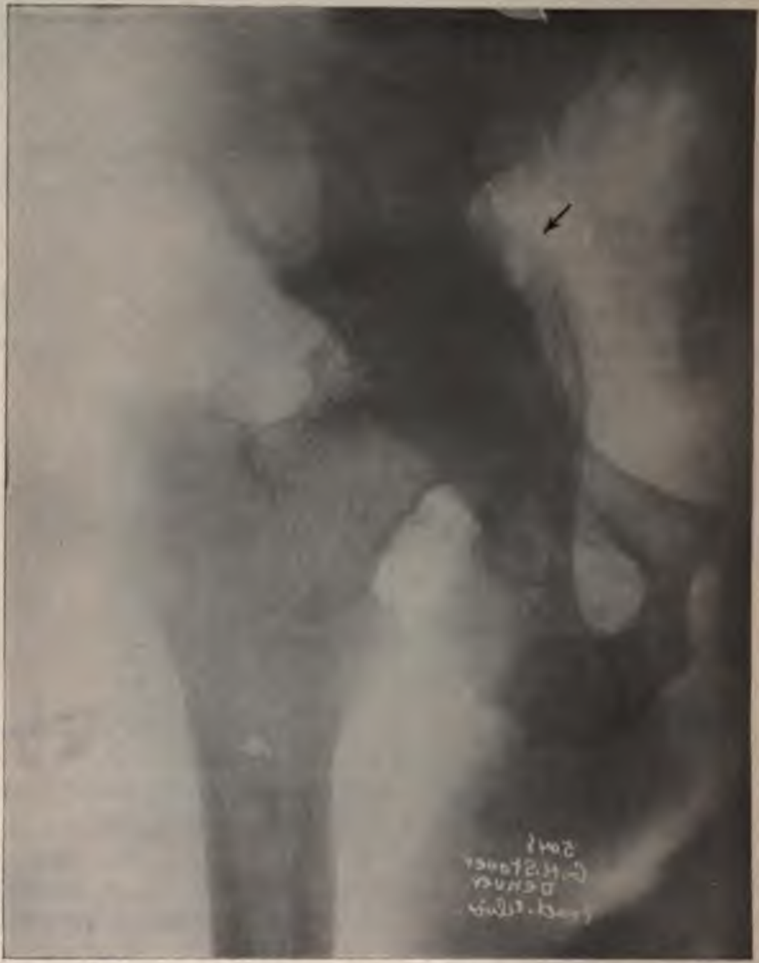

Fig. 564.—Fracture of the pelvis through the bottom of the acetabulum due to trauma transmitted through the femur.

strong and it not infrequently happens that the counter-arches are fractured by excessive strains which have been applied to the main arches, without however breaking the latter. When antero-posterior force is applied the anterior portion of the pelvis gives way first, and then, if the force continues to act, the lateral portions of the pelvis are forced apart and there is likely to be injury in the region of the sacro-iliac joints. Transverse violence breaks the counter-arches forcing them forward, after which the main arches give way and we have fracture of the lateral portions of the pelvis or in the region of the sacro-iliac synchondrosis. In the first instance fracture of the anterior portion is by direct violence, while the second is by indirect violence. The action of violence on the pelvis might be likened to the mechanism of fracture of the skull, which results in fracture "by bending" and fracture "by bursting." Isolated fracture of the posterior portion of the pelvis only occurs in the presence of well localized and severe trauma. Numerous muscles are attached to the surface of the pelvis, both internally and externally, and these muscles each have a displacing tendency when fracture is present. Their origins and insertions should be understood in order that we may appreciate their influence on deformity.

To the crest of the ilium we have the erector spinæ, the latissimus dorsi, quadratus lumborum, external oblique, internal oblique and transversus abdominalis, tensor vaginæ femoris and sartorius. These muscles, with the exception of the last two, pull in an upward, or upward and inward direction, while the last two pull downward toward the thigh. The external surface of the ilium affords attachment to the three gluteal muscles, while the inner surface, above the brim of the true pelvis, is taken up by the origin of the iliacus. The pubis affords attachment to the conjoined tendon of the internal oblique and transversalis, the tendon of the external oblique, rectus and pyramidalis. All the muscles of this group pull upward, or upward and outward. The anterior surface of the pubis and the ischiopubic rami afford attachment to the adductor muscles; the tuber ischii to the semimembranosus, semitendinosus and the biceps, all of which have a downward pull. When the fragment is free the tendency is toward displacement in the line of pull of the muscle attached. The vascular and nervous structures passing under Poupart's ligament lie close to the ascending ramus of the pubis and may be injured by displaced fragments.

We have the internal pudic artery running on the inner surface of the ischiopubic rami where it may be injured when this portion of the pelvis is fractured. The structures passing through the greater and lesser sciatic foramina are also to be considered in fracture of the posterior portion of the pelvis.

The bladder lies behind the pubes and is more or less attached to the bones by fibrous tissue; it may be injured by compression when the viscus is full, by the penetration of fragments or by the pull of the connective tissue when portions of the bone are displaced. The two layers of the triangular ligament, composed of heavy fibrous tissue, are firmly attached to the ischiopubic rami which form the subpubic arch. When this arch is fractured the ligament is usually torn and since the urethra passes through the ligament it may also suffer injury. The rectum is situated in the posterior portion of the pelvis, follows the curve of the anterior surface of the sacrum and coccyx, and in this protected position is rarely injured. The nerves passing through the sacrum and in close relation to the coccyx may be injured when this region of the pelvis is fractured.

Etiology.—Fracture of the pelvis is usually the result of great violence such as occurs when the patient is caught between two railroad cars or crushed beneath falling rock in mine accidents. Falls from heights may produce the condition, the force often being transmitted through the femora or tubera ischiorum. Fracture of the pelvis is comparatively a rare accident, constituting about one-half percent of all fractures. The flaring ilia are more frequently fractured than is the true pelvis because of their lighter structure and more exposed positions.

Classification and Pathology.—The pelvis is a complex structure both in its bony parts and its relation to viscera. The different portions of the pelvis should be studied individually, and then the pelvis as a whole is to be considered with reference to its various functions. Like the skull, the most important feature of fracture of the pelvis consists of the injury which may be sustained by adjacent soft tissues, in other words the complications occurring in fracture of the pelvis are far more serious than the fracture itself.

Fracture of the pelvis may be divided clinically into *complicated and uncomplicated cases*. Uncomplicated fracture commonly occurs in isolated fracture of some one of the three bones forming the os innominatum while the complicated type is most commonly seen when the pelvic girdle is fractured.

Uncomplicated fracture most frequently occurs in:

1. The upper expanded portion of the ilium.
2. The rim of the acetabulum.
3. The tuberosity of the ischium.
4. The coccyx and tip of the sacrum.

The complicated type is represented by:

1. Separation of the symphysis pubis.
2. Fracture of the pubic and ischiopubic rami.
3. Vertical fracture of the lateral portions in the region of the acetabulum.
4. Separation of the sacro-iliac joints.
5. Transverse fracture of the sacrum.

Considerable useless distinction has been made between fracture and dislocation of the pelvis. Probably the only real dislocation occurring in the pelvis is that of the coccyx. The so-called dislocations described as having taken place in the sacro-iliac synchondrosis are at most only subluxations, usually complicated by fracture in the immediate neighborhood of the joint. In most of the reported cases of sacro-iliac dislocation fracture has been recognized as a complication and in other instances the report would indicate that the presence of fracture had not been properly excluded by X-ray examination. Separation of the symphysis may be considered as a dislocation though it is probably more in accordance with the pathological facts to place it under the heading of fractures.

Symptoms.—The symptoms of fracture of the pelvis will vary according to the region of the injury and the complications present. Isolated fracture of a small portion of the pelvis such as the anterior superior iliac spine will not, as a rule, give rise to more than local symptoms. There will be more or less localized pain which is increased when the patient moves about. On examination we find abnormal mobility, crepitus, tenderness, swelling, etc. But, on the other hand, when the pelvic girdle is fractured and complications are present, we have a very different clinical picture. Shock is a prominent symptom as evidenced by pallor, cold clammy skin, weak rapid pulse, etc. Collapse and unconsciousness may supervene in pronounced cases. If conscious the patient suffers intense pain and deformity of the true pelvis is present to a greater or less degree. It is often possible to elicit abnormal mobility and crepitus upon examination though the surgeon should exercise the greatest care to avoid further injury to the viscera by manipulation. Inability to walk may be due to pain, shock and visceral injury or it may be the result of mechanical disturbance in the weight-carrying function of the pelvis. If that portion of the pelvis bearing the acetabulum is displaced upward there will be shortening in the lower extremity of the same side. To these symptoms will be added those peculiar to the complications present.

Of the uncomplicated fractures of the pelvis, isolated fracture of the upper expanded portion of the ilium is the most common, while fracture of the anterior portion of the pelvic ring is the most frequent representative of the complicated type.

The symptoms occurring in the different types of uncomplicated fracture of the pelvis are as follows:

1. *Fracture of the upper expanded portion of the ilium* will be accompanied by pain in the region of the injury, tenderness and often swelling. Ecchymosis frequently develops after the first twelve or twenty-four hours. Pain will be increased by any motion which calls into activity the muscles attached to the fragment or fragments. When the course of the fracture is horizontal the crest may show marked upward displacement. The line of fracture will frequently be found running downward and forward from the middle of the crest, or less commonly downward and backward from the same point. The fracture is usually due to direct violence and accordingly bruises or abrasions are frequently seen in the skin over the region of injury. In rare instances the intestines lying in the hollow of the ilium may suffer injury, producing symptoms of shock and peritonitis. When the fracture is confined to the region of the anterior superior iliac spine the fragment may be displaced forward and outward due to the combined actions of the abdominal muscles, sartorius and tensor vaginæ femoris. When the fragment includes only a small part of the crest and only a small portion of the abdominal muscles are attached, the action of the thigh muscles just mentioned will be practically unopposed, resulting in downward displacement.

Crepitus is usually present but is by no means constant, since the fragments are not always in contact. Relaxation of the muscles of the abdomen and thigh will render palpation of the fragments easier and often enable the surgeon to elicit crepitus which would otherwise be absent. This may be accomplished by placing pillows beneath the patient's shoulders and flexing the thighs.

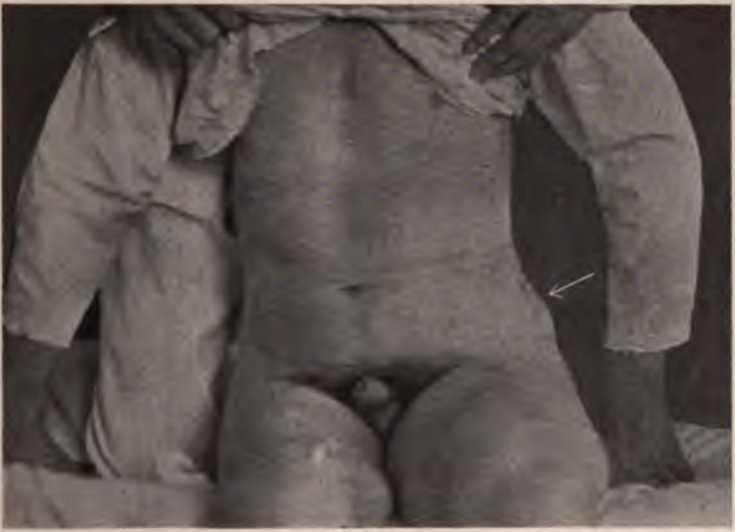

Fig. 565.

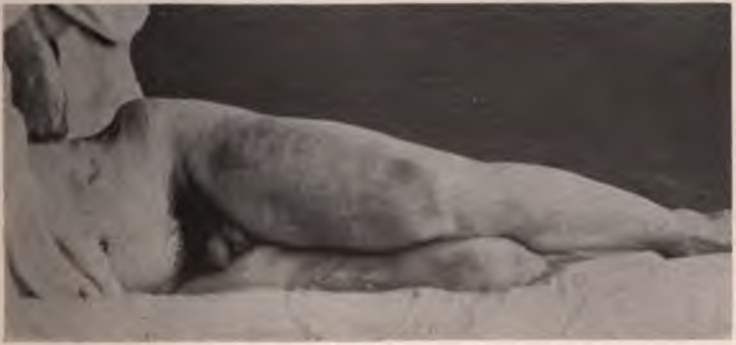

Fig. 566.

Figs. 565 and 566.—Fracture of the left ilium with tearing away of the abdominal muscles from the iliac crest. Note the change in outline with the patient in the lateral recumbent position. (Atrophy of right thigh result of old amputation of right leg.)

2. *Fracture of the rim of the acetabulum* does not occur except as a complication of displacements of the head of the femur. The upper posterior part of the rim is the portion of the acetabular cir-

cumference most frequently detached by the head of the femur as it leaves the cavity. Fracture of the rim of the acetabulum with displacement of the femoral head results in shortening of the limb of the affected side though the position assumed is not necessarily characteristic of dorsal dislocation of the hip. Slight manipulation of the thigh with traction is usually sufficient to bring the head of the femur back into place though the deformity recurs either immediately or within a few hours following reduction. It differs from dislocation of the hip in the ease with which reduction is accomplished and the tendency to recurrence of deformity. The condition however closely resembles fracture of the neck of the femur, having frequently been mistaken for it.

In fracture of the neck of the femur the arc described by the trochanter when the thigh is rotated is of shorter radius than normal. In fracture of the rim of the acetabulum this arc is normal as may be demonstrated by comparison with the opposite side. This difference, however, is often slight and difficult to determine, so that the use of the X-ray will frequently be necessary to determine the pathology of the case. The fragment usually follows the head when the latter is returned to the acetabulum, and crepitus will be produced as the fractured surfaces pass each other. This crepitus may be as pronounced as in fracture of the hip, or it may be exceedingly indistinct according to the position of the fragment.

3. *Fracture of the tuberosity of the ischium* is an exceedingly rare condition being the result of severe localized trauma. The condition is therefore likely to be accompanied by wounds of the soft parts which may reach to the bone, rendering the fracture compound. Abnormal mobility and crepitus may be elicited by palpation through the rectum or vagina, while the opposite hand gives counter-pressure through the gluteal muscles. Local pain, tenderness, etc., will be present.

4. *The coccyx may be fractured or dislocated* by direct violence acting either from without or within. It most often follows falls on the buttocks and may be displaced forward, laterally or backward, the latter being the result of forces acting from within the pelvis, such as the descending head of the child. The distinction between fracture and dislocation of this bone has been the subject of much discussion between certain writers, but for practically clinical purposes it matters little since the symptoms and treatment are identical. The pain in fracture or dislocation of the coccyx may be

surprisingly severe considering the actual damage done. Before reduction is accomplished the patient usually presents the symptoms of agonizing pain which radiates up the back and down the dorsal aspect of the thighs from the seat of injury. Even after the suffering has been relieved by correcting the displacement it will be many days before the patient can move about with any degree of comfort. The fracture may take place through the lower end of the sacrum so that a portion of this bone is displaced with the coccyx. The higher the fracture in the sacrum the greater the likelihood of injury to the nerves contained within the sacral canal and emerging through the sacral foramina. Injury to these nerves may produce pain, numbness, loss of function, etc., throughout the region of their distribution, and in severe cases to trophic disturbances with sores or sloughs in the skin covering the coccyx and lower end of the sacrum. The coccyx and sacrum become one bone in the aged so that fracture of

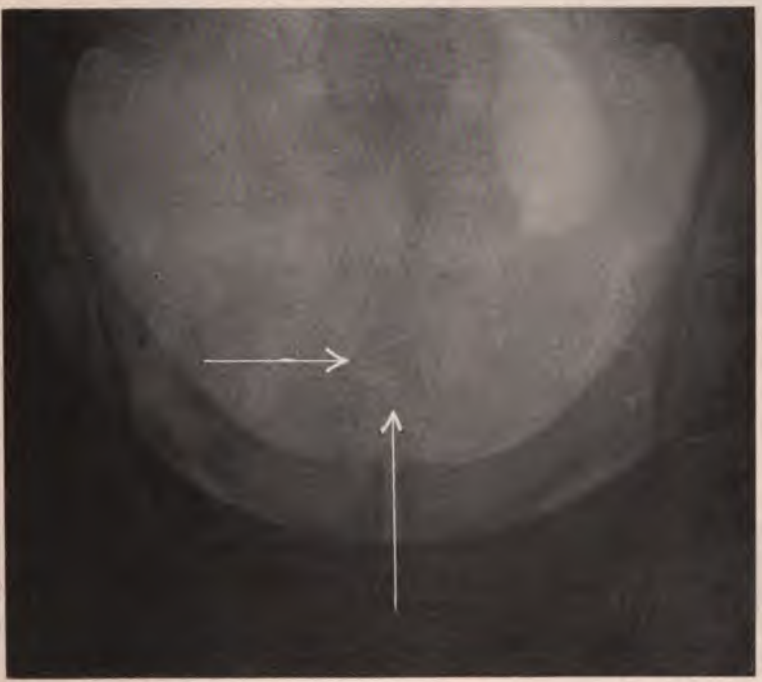

Fig. 567.—Lateral dislocation of the coccyx. The arrows point to the coccyx which has been outlined to accentuate its position. The lower arrow passes through the symphysis pubis.

the tip of the sacrum is more likely to occur after the articulation has been obliterated.

The usual displacement of the coccyx is angular and forward so that the tip of the bone may be felt pointing forward when the examining finger is introduced into the rectum. This displacement encroaches upon the cavity of the rectum, rendering bowel movements extremely painful. The lateral and posterior displacements, which are extremely rare, do not tend to recur following reduction; the anterior displacement however does tend to recur as a result of the action of the attached muscles. Lateral displacements may be palpated through the rectum; posterior displacements will be accompanied by an abnormal prominence in the lower part of the gluteal cleft.

The symptoms occurring in complicated fracture of the pelvis will depend on the region of the pelvis injured, together with the nature and extent of the injury sustained by the soft parts in the region of the fracture. When any portion of the pelvic girdle is fractured numerous complications may exist so that it will be best to consider the bone injuries first in the order previously set down, after which the complications will be taken up.

The mechanism and pathology of fracture of the pelvic girdle are of secondary importance when compared to the complications commonly found accompanying this condition.

1. *Separation of the symphysis pubis* may be the result of indirect violence forcing the ossa innominata apart, due to the overaction of the adductor group of muscles while the thighs are in abduction, or to the spreading action of the fœtus as it descends through the parturient canal. The separation of the pubes may be felt and in many instances seen. Separation of over one and a half inches is, as a rule, accompanied by rupture of the anterior sacro-iliac ligaments or fracture in some other portion of the pelvic ring.

With separation of the symphysis the patient suffers considerable pain and the weight bearing function of the pelvis is interfered with as a result of the dissolution of the counter-arches. Rupture of the ligaments and loosening of one of the sacro-iliac joints will allow one os innominatum to be displaced, usually upward. Symphyseal separation may be associated with fracture of the pelvis or with loosening of one or both sacro-iliac joints. One pubic bone may be displaced behind the other and when such is the case it is usually very difficult to reduce the deformity. The common complication is rupture of the urethra or bladder, the symptoms of which will be described later.

2. *Fracture of the anterior portion of the pelvic ring* occurs more frequently than any of the other fractures in this group. The details of the lines of fractures vary greatly. Both rami of the pubis are usually fractured, the upper one anterior to the ilio-pectineal eminence and the lower near the junction of the descending pubic with the ischial ramus. The condition is not infrequently bilateral. Deformity is usually present and can be detected by palpation. The condition may be the result of violence applied to the pelvis in the antero-posterior direction or it may be due to lateral squeezing. Fractures in the lateral or posterior portions of the pelvic ring are common as complications, and are seen in instances in which the causative trauma continues to act after the anterior portion has been fractured. The patient is unable to walk, pain is severe, and shock often pronounced, especially in the presence of visceral complications. Rupture of the bladder and injury to the urethra are common as complications (see page 509).

3. *Fracture of the lateral portions of the pelvis* in the region of the acetabulum occurs in conjunction with fracture of the anterior portion of the ring as previously explained, and also as a result of trauma transmitted through the head and neck of the femur. The first named type of fracture is more or less vertical, passing from the crest of the ilium to the great sacro-sciatic foramen. The line of fracture frequently branches in its upper end. It may pass into or cross the sacro-iliac joint involving the sacrum: in other instances it comes out below the anterior inferior iliac spine. When it crosses the sacro-iliac joint it may follow more or less closely the line of the articulation, or it may follow the sacral foramina separating the lateral mass of the sacrum from the rest of the bone. The directions which the lines of fracture may take in the lateral portions of the pelvis are very variable and accordingly two cases will seldom show the same deformity. The fact that the femur articulates with this portion of the pelvis often gives rise to symptoms of importance. The lower extremity of the affected side usually lies helpless and is shorter than normal because of the displacement of the acetabulum. The muscles of the thigh are in spasm and any attempt at passive motion is seriously objected to

by the patient. Abnormal mobility and crepitus can, as a rule, be elicited with ease by direct palpation or manipulation of the thigh, and the pelvic deformity is often plainly visible. Injury to the acetabulum and adjoining pelvis resulting from trauma transmitted through the femur is rare, because when violence is applied to the trochanter the neck of the femur is much more liable to fracture than is the pelvis. The condition, however, does occasionally occur and a variety of fractures may result when the pelvis is injured in this manner: the acetabulum may be "broken out," so to speak, of the rest of the pelvis with three lines of fracture, one from a point below the antero-inferior spine to the great sacro-sciatic notch, the second across the ascending ramus of the pubis and the third across the body of the ischium below the acetabulum; another result is that the violence applied to the acetabulum produces radiating fractures which, following the lines of least resistance, reach the sacro-sciatic notch, thyroid foramen and rim of the pelvis; in addition we may have injury of the bone at the bottom of the acetabular cavity without fracture of adjoining portions of the pelvis. A rare condition is sometimes seen in which the head of the femur is driven through the bottom of the acetabulum into the pelvic cavity. The symptoms of deformity and disturbance in function will vary with the pathology of the condition. When the acetabulum is fractured there is likely to be shortening of the lower extremity, abnormal mobility of the upper end of the femur and crepitus when the thigh is manipulated. When the head of the femur is driven through the acetabulum there will be abnormal fixation of the upper end of the femur, mesial displacement of the trochanter as palpated externally, and the patient will be able to bear the weight of the body on the limb of the affected side since the ring of the pelvis is not fractured and the weight is transmitted to the neck of the femur instead of to the head. The shock and pain, however, will usually be sufficient to prevent the patient attempting anything in the way of walking. Fracture of the pelvis by lateral compression is usually preceded by fracture of the "tie arches" composing the anterior part of the ring, so that the symptoms of fracture of both these portions of the pelvis will be present at the same time.

4. *Separation of the sacro-iliac synchondrosis*, as an isolated injury, is an extremely rare condition. It occurs sometimes in conjunction with fracture of the anterior portion of the pelvic

ring or separation of the symphysis pubis. Inward displacement of the lateral portions of the pelvis, such as occurs in transverse crushes, may result in rupture of the posterior ligaments behind the articular surfaces. Spreading of the pelvis throws the strain on the anterior sacro-iliac ligaments, which rupture, allowing the anterior aspect of the joint to gape. The strength of these ligaments, however, is so great that fracture in the adjoining bone is more frequently produced than rupture of the ligament itself. Displacement in one or both sacro-iliac joints, or separation of all three pelvic articulations is known to have taken place, but such conditions are very rare. Laxity or rupture of the ligaments of the sacro-iliac joints will allow an upward and outward displacement of the ilium if the patient attempts to sit or stand. Disturbances in function following injury to the pelvic articulations will give rise to symptoms similar to those occurring in fracture of the same region. The sacro-iliac joints are not infrequently subject to sprains in falls and blows on the pelvis, and although the condition is by no means a dislocation, it deserves mention. There is more or less pain in the joint when the patient moves about, and pressure on the anterior superior spines produces pain in the region of the injury. The condition is usually not serious, being followed by prompt recovery with rest in bed for a few days.

5. *Transverse fracture of the sacrum* is the result of severe localized trauma and is fortunately a rare condition. A small portion of the sacrum may be displaced with the coccyx but this condition is described under fracture of the coccyx. The fragment in transverse fracture of the sacrum is usually displaced forward, projecting into the cavity of the pelvis and is commonly accompanied by injury to the rectum and the nerves contained within the sacral canal. The displacement is easily detected by palpation. Severe pain, radiating up the back and down the thighs, may be present. Shock is often pronounced. Paralysis of the bladder and rectum, due to injury of the nerves supplying these structures as they pass through the sacrum, is not uncommon. Paralysis of the lower leg type has been noted in some cases. The displacement is produced by the original trauma and the action of the attached muscles. The deformity usually recurs promptly following reduction.

Diagnosis.—When fracture of the pelvis is suspected the examination should be conducted systematically in order that the full extent of the injury may be recognized. Moreover the examination should not be considered complete as soon as we find one line of fracture, since multiple fracture and visceral complications are common. The patient should be placed in a position which is accessible and convenient for the surgeon, preferably an operating table, and unless there are special contraindications it is advisable to administer a short anesthetic. The pelvic girdle is covered with a number of muscles and many of its parts are deeply situated, yet by proper palpation fracture and articular displacements can, as a rule, be determined without difficulty. By inspection alone it is often possible to detect asymmetry of the two sides of the pelvis, raising of one of the ossa innominata, or the median depression of symphyseal separation. The shortening and helpless attitude in which the lower extremity may lie is indicative of fracture of the femur or pelvis. Palpation will usually elicit crepitus and abnormal mobility in the presence of fracture or separation. With the patient in the dorsal position and the pelvis solidly supported, backward pressure is made with the palms of the hands on the antero-superior iliac spines, then the iliac crests are crowded together and finally antero-posterior pressure is exerted with one hand over the symphysis and the other on the sacrum. Pressure in these directions will usually elicit mobility and crepitus if the fracture has passed through the pelvic girdle. Due care should be exercised to avoid further injury to the viscera in manipulating the parts since the examination may thus inflict more serious injury. The pubes and their ascending rami are near the surface and their outline may be followed throughout. The mesial borders of the ischio-pubic rami may be palpated at the lateral boundaries of the perineum with the thighs abducted. The anterior superior iliac spines are subcutaneous and the iliac crests may be palpated throughout their extent, terminating posteriorly in the postero-superior iliac spines. The tuberosity of the ischium may be palpated with the fingertips of one hand resting in the lower part of the gluteal cleft while the opposite hand makes counter-pressure through the buttock. It may also be palpated through the rectum or vagina. The spines of the sacrum may be palpated throughout but the remainder of the posterior surface of the bone is obscured to touch by the heavy fascia covering the lower end of the erector spinæ mass. If the finger be passed into the rectum and the thumb opposed posteriorly the coccyx may be thoroughly palpated, and the presence of abnormal mobility and crepitus determined when present. The presence of fracture is, as a rule, easily recognized by palpation as above described, but it is often impossible to determine the details without employing the X-ray.

Treatment.—The treatment of fracture of the pelvis aside from the complications is usually a simple matter. If the deformity is not great immobilization and rest in bed will be all that is required. In *fracture of the crest of the ilium* a body swathe may be used or adhesive straps may be employed to steady the fragment. Too much pressure should be avoided, as it may displace the fragment inward, thus increasing the deformity. Rest in bed is necessary and the patient should be warned against undue use of the abdominal muscles. The bowels should be kept soft to avoid straining at stool. Moderate deformity does not mean impairment of function and seldom requires special measures for its correction. A flattened hip in a young woman, however, is often considered a serious matter and we may be called upon to secure the fragment by operation for the correction of deformity. *Fracture of the rim of the acetabulum* is to be treated similarly to fracture of the hip and will be considered with the treatment of fractures of the upper end of the femur. *Fracture of the tuberosity of the ischium* rarely shows great displacement and recovery with moderate deformity is followed by good function. Rest in bed and a pneumatic ring to relieve the region of fracture from pressure will constitute the essentials of treatment. If the tuberosity, however, shows enough inward displacement to encroach on the transverse diameter of the birth canal in a woman of the child-bearing period, it is best to cut down on the fragment before union commences and secure it in place with wire or some other form of suture material. *Fracture or dislocation of the coccyx* calls for immediate reduction to relieve the suffering and if necessary opiates should be used in addition. All of the displacements except the anterior show little or no tendency to recurrence and not much in the way of treatment will be required aside from reduction and relief of pain. The patient should be kept in bed for a week or so or until the extreme tenderness has subsided. During this time the use of a pneumatic ring will add greatly to the patient's comfort. In fracture or dislocation with anterior displacement it is difficult to keep the fragment in reduction, because of the muscles attached to the coccyx. The condition has been treated by packing the rectum and the exhibition of opiates to produce constipation. If a large rubber tube, rolled in gauze, is introduced it will allow the escape of flatus and liquid fœces without removing the dressing. When this dressing is used the bowels should be kept liquid by laxatives. In any case the rectal packing will have to be maintained until the callus is sufficiently firm to prevent the recurrence of deformity. It should be renewed often enough during the after-treatment to keep the parts clean and avoid rectal irritation. Vaseline facilitates introduction and is less irritating to the mucosa than plain gauze. If these measures do not control the tendency toward displacement or pain following the injury persists and defecation is painful because of the anterior displacement, excision of the coccyx is indicated and will be followed by relief and no disturbance in function.

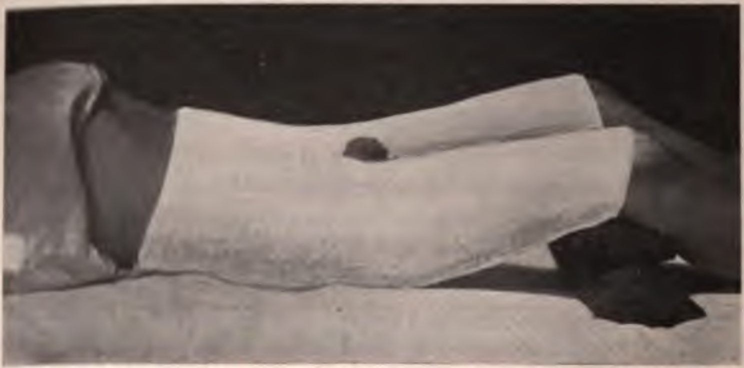

Fig. 568.—Plaster of Paris double spica of trunk and both thighs for the treatment of fracture of the pelvis. The thighs should be slightly flexed and abducted to allow proper care of the patient and use of the bed pan.

In the above isolated fractures of the pelvis the patient may be made comparatively comfortable by rest in bed and proper nursing, but when the *ring of the pelvis* is fractured the condition is much more serious and difficult to treat. The element of importance in *separation of the symphysis, fracture of the pubic and ischio-pubic rami, lateral fracture of the pelvis* and *separation of the sacro-iliac joints* is the breaking of the pelvic girdle and the likelihood of visceral complications. The indications, therefore, in the treatment of these conditions will be to secure immobilization of the pelvic ring and provide for the complications as soon as they are recognized. The various visceral complications are not peculiar to any one form of fracture of the pelvic ring and because of this fact they will be considered under a separate heading (see page 509). A Bradford bed-frame or some substitute is essential to prevent disturbing the fragments whenever the bed-pan is used and to keep the bed and patient properly clean. In place of the Bradford bed-frame we may employ a double plaster of Paris spica extending from the waist to the knees, and in this manner the pelvis is secured so that the patient may be rolled from side to side, the bed-pan used and the clothes changed without disturbing the parts or increasing the suffering. The cast should be applied with the thighs slightly abducted and with moderate flexion at the knees and hips, thus giving ready access to the anal region and the genitals, besides securing a more comfortable position for the patient. Traction on the thigh may reduce deformity when the portion of the ring to which the femur is attached is driven in. By manipulation it is sometimes possible to correct some of the displacements. The treatment of fracture of the pelvic girdle consists mainly in the treatment of the complications which accompany the condition.

Complications.—Complications very rarely occur except in cases in which the pelvic girdle is fractured, but their presence in isolated fracture of some of the bones of the pelvis or even in cases of abdominal or perineal trauma without fracture should not be lost sight of. The visceral injuries accompanying fracture of the pelvic girdle are far more important than the fracture itself, being responsible for the high mortality following this fracture. Rupture of the urethra, rupture of the bladder, rupture of the bowel, injury to vessels (especially the external iliacs) and injury to nerves (especially the sacral and coccygeal) are among the complications most common in fracture of the pelvis. Renal injury sometimes occurs as an associated condition.

The *symptoms of rupture of the urethra* will depend on the region of the canal injured. Injury is most frequently sustained in the membranous portion, as the canal emerges from the superficial layer of the triangular ligament. If the tear in the urethra is outside the cut-off muscle the hemorrhage from the meatus will be more or less continuous. There is often a dribbling of blood for some time following the accident, which grows less and finally stops only to begin again when urine is passed or micturition attempted. Pain and tenesmus are usually pronounced. Swelling of sudden onset, due to urinary accumulation, is seen in the perineum and if not relieved soon extensively infiltrates the surrounding tissues. The catheter usually meets obstruction when it encounters the site of rupture. If the floor of the urethra is torn catheterization may sometimes be accomplished by following the roof with a metal instrument. Complete tear almost always requires operative intervention to enter the bladder. If the rupture is behind the cut-off muscle the blood will flow back into the bladder, appearing at the meatus only with micturition. If the rupture is complete, retention is the rule with occasional dribbling of bloody urine. When retention is present the symptoms of distended bladder will supervene within a few hours. The diagnosis of rupture of the urethra is made on the symptoms enumerated above. In some instances the tear in the urethra may be inspected by means of the urethrascope or posterior endoscope or better still the cystourethrascope.

Treatment of rupture of the urethra.—In rupture of the urethra the prime indication is for prompt, continuous and complete drainage of the bladder. Cases in which the passage of the catheter has been possible have been successfully treated by means of continuous catheterization and suction apparatus. By far the safest method however consists in prompt external urethrotomy followed by direct drainage of the bladder through a rectal tube in the perineum connected by means of rubber tubing with a bottle beneath the bed. Perineal drainage instituted early will accomplish more in preventing urinary infiltration than anything else. When the tear is complete the roof of the urethra should be brought together and secured by suture during the operation. The most satisfactory catheter in these cases is the rectal tube. In some instances considerable difficulty is experienced in finding the proximal end of the torn urethra and in such cases it is better to enter the bladder suprapubically and do a retrograde catheterization rather than to prolong the search in the perineum with the patient already suffering considerable shock from the accident. During the treatment of this condition it is always advisable to determine the condition of the bladder to avoid overlooking complications of this viscus.

Symptoms of rupture of the bladder.—Shock is always a prominent symptom aside from the shock occurring in fracture of the pelvis. Pain is pronounced and tenderness present. If the rupture is extraperitoneal the patient passes bloody urine which is not preceded by blood as in urethral injury. Suprapubic swelling due to infiltration of urine into the space of Retzius makes its appearance a few hours following the injury. When the rupture is intraperitoneal the urine passes from the bladder into the peritoneal cavity and accordingly the viscus does not become distended. If sufficient urine collects in the abdominal cavity, dullness on percussion may be noted in the flanks. The patient is unable to pass urine although tenesmus is present and frequent painful attempts at micturition are made.

Diagnosis of rupture of the bladder will be followed by the symptoms peculiar to this injury as described above. In addition we may test the walls of the bladder by introducing a measured quantity of sterile salt solution through a catheter and remeasuring it after it has been withdrawn. If the bladder has been ruptured intraperitoneally it will be impossible to fill the viscus, and the fluid when withdrawn will be much less than the quantity introduced. When the rupture is extraperitoneal the loss of fluid will often be too small to detect. The catheter should not be introduced further than is necessary to reach the bladder since in some cases of intraperitoneal rupture it may pass through the rent in the bladder into the peritoneal cavity, thus evacuating urine which has escaped from the bladder or salt solution which has been introduced for diagnostic purposes. This method is not ideal and has been condemned by some genito-urinary surgeons, yet it is the best we have and nothing is more fatal to the patient than the expectant plan of treatment followed because of ignorance of the conditions present. The questionable damage done by the passage of salt solution (previously sterilized) from the ruptured bladder into the abdominal cavity and followed by operation is more than outweighed by the benefit the patient derives from a positive diagnosis and prompt surgical treatment. The cystoscope is valueless in intraperitoneal rupture since the bladder cannot be distended. When the rupture is extraperitoneal it will sometimes be possible to inspect the injury by means of this instrument in competent hands. The hemorrhage, however, is usually sufficient to obscure the water with which the bladder is distended, so rapidly that vision is rendered unsatisfactory or impossible.

Treatment of rupture of the bladder.—Rupture of the bladder calls for immediate operative intervention if we expect to save the patient. In the intraperitoneal form of rupture the rent must be closed through an abdominal incision and the bladder drained from below through a permanent perineal tube to prevent distention of the viscus and tension on the sutures. In extraperitoneal rupture the tear is frequently situated in the lower anterior aspect of the bladder or the region of the trigone, and should be repaired with fine absorbable suture material. The situation, however, of these extraperitoneal tears is inaccessible and difficult to operate upon and the condition of shock in which we find the patient often precludes any prolonged operation or anesthetic. It is therefore best in many cases of extraperitoneal tear to establish free perineal drainage at once, leaving the rent to take care of itself.

PART III.

LOWER EXTREMITY.

CHAPTER XXXVI.

DISLOCATIONS OF THE HIP.

Surgical Anatomy.—The hip-joint is a typical ball-and-socket articulation, and the depth of the acetabulum is such that the integrity of the joint is much less dependent upon the ligaments than is the case in the shoulder-joint. Numerous muscles are attached to the upper end of the femur and the great trochanter, all of which exert more or less of an upward or inward pull, their action being much more apparent in fracture of the neck of the femur than in dislocations of the hip. The muscle of greatest importance in this region is the obturator internus which is inserted into the digital fossa after having emerged from the pelvic cavity through the lesser sacro-sciatic notch. If the head of the bone passes under this tendon we have the sciatic form of dislocation. When it passes over the muscle we have the iliac type in which the head of the bone rests on the dorsum ilii. The hip has five ligaments: ligamentum teres, the capsule, the cotyloid, transverse, and ilio-femoral. The *ligamentum teres* passes from the ovoid depression on the head of the femur to the margins of the fossa acetabuli. The *capsular ligament* surrounds the joint, is attached at its inner end to the margins of the acetabulum, while the opposite end is attached to the femoral neck. The anterior portion of the capsule extends downward and outward as far as the spiral line of the femur, while the posterior portion of this ligament reaches to within a half inch of the posterior intertrochanteric line. The capsule is lined with synovial membrane and possesses a number of accessory thickenings along the lines of the greatest and most frequent strains. The upper and anterior portion of this tube-like ligament is the heaviest. The posterior inferior portion is comparatively thin, loose and lax. The *cotyloid ligament* is an intracapsular fibro-cartilaginous ring attached to the margins of the acetabulum; it serves to deepen the cavity and strengthen the joint. Where it crosses the cotyloid notch, it is known as the *transverse ligament*. The above ligaments are all more or less essential factors in the hip, but the ligament of by far the greatest importance is the *ilio-femoral* or *Y-ligament of Bigelow.* This consists of an accessory thickening in the anterior portion of the capsule. Its lower extremity is attached to the anterior intertrochanteric line, while its upper end is attached, with the straight head of the rectus, to the anterior inferior iliac spine. In extension of the thigh this ligament is tense, and limits motion at the hip; in flexion it is relaxed. In a person of average build it is said to possess a tensile strength of two hundred and fifty pounds or more, and thus it will be readily understood that this ligament is rarely torn in dislocations of the hip.

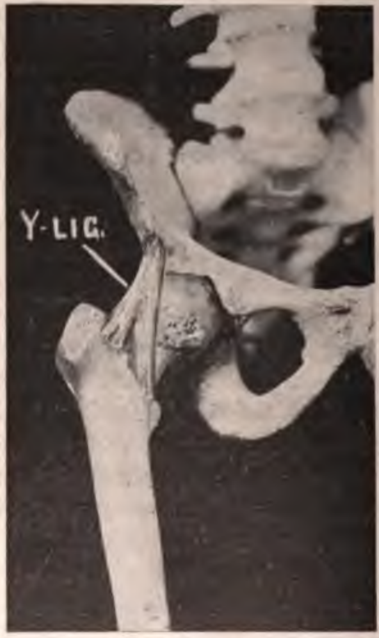

Fig. 569.—The ilio-femoral or Y-ligament of Bigelow, a most important structure in dislocations of the hip.

The head of the femur when displaced may lie anywhere about the acetabulum, depending on the manner in which violence was applied at the time of the accident, and the subsequent action of the muscles and ligaments attached to the bone. Although the head may lie in almost any position around the acetabular ring, yet it almost invariably leaves the joint through a rent in the lower portion of the capsule. After escaping from the socket it usually rides upward either in front of, or behind the acetabulum. Accordingly numerous classifications have been given of dislocations of the hip, all of them based on the position occupied by the displaced head. There are two main groups deserving of consideration, namely, anterior and posterior. The resultant attitude assumed by the lower extremity is purely a question of mechanics, depending upon the relations of the displaced head and the influence of the Y-ligament. Whatever position the femoral head may find, the distance between the anterior inferior spine and the spiral line cannot exceed the length of the ilio-femoral ligament. The action of this ligament, under these conditions, might be likened to that of a "toggle joint" or "shackle," which, though movable at one end, maintains a more or less fixed relation between the attached objects. If the head, therefore, is displaced outward and backward, the knee must of necessity come forward and inward, and in like manner the other characteristic deformities accompanying the various dislocations of the hip, may be readily understood if one appreciates the anatomy, particularly the action of the ilio-femoral ligament.

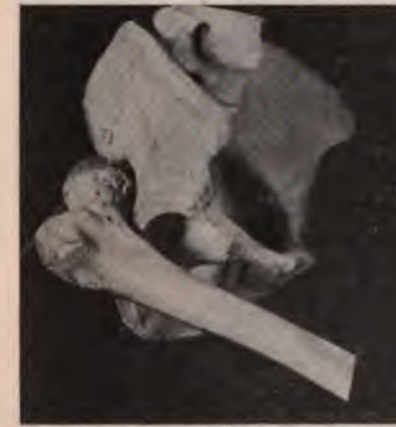

Fig. 570.

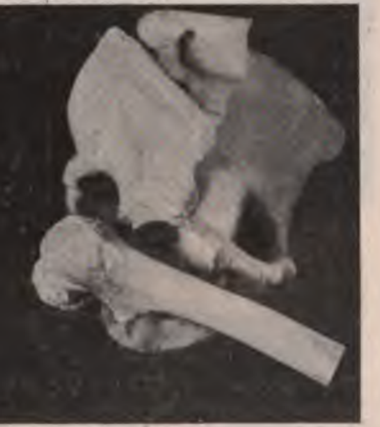

Fig. 571.

Fig. 570.—Iliac dislocation of the hip. The higher the head rests on the ilium the more pronounced will be the inward rotation of the thigh provided the Y-ligament is not ruptured.

Fig. 571.—Sciatic dislocation of the hip. The head rests in the sciatic notch.

A second element in the production of deformity is the angle at which the femoral neck joins the shaft, and the consequent leverage exerted by the neck when the head of the bone is out of the socket. Thus, if the posterior aspect of the neck lies in contact with the os innominatum, as in the anterior displacements, outward rotation must be the result; when the reverse condition is true, the anterior surface of the neck lying in contact with the hip bone, as in posterior dislocations, inward rotation of the thigh will be present. The depth of the socket and the heavy ligaments

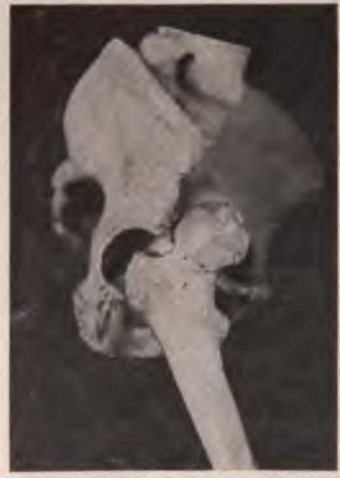

Fig. 572.

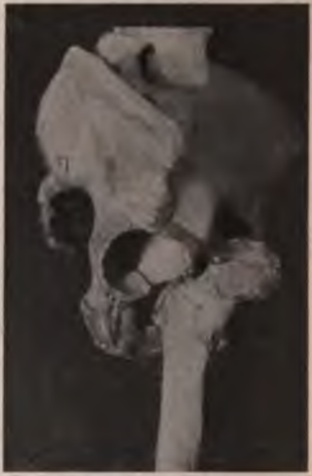

Fig. 573.

Fig. 572.—Ilio-pectineal dislocation of the hip.
Fig. 573.—Pubic dislocation of the hip.

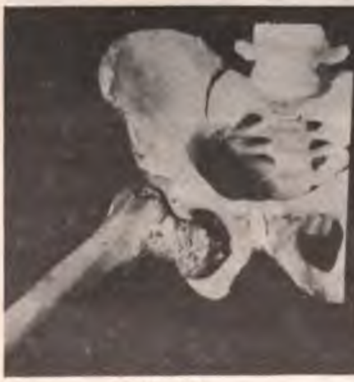

Fig. 574.

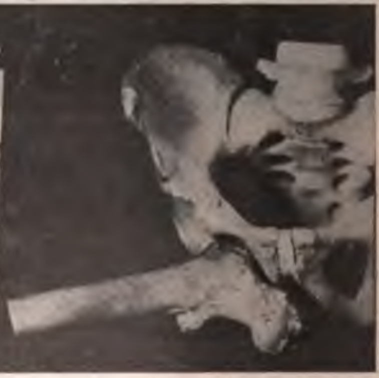

Fig. 575.

Fig. 574.—Obturator or thyroid dislocation of the hip.
Fig. 575.—Perineal dislocation; an exaggeration of the obturator type.

surrounding the joint account for the extreme rarity of dislocation of this articulation.

If the antero-superior iliac spine be connected by a line with the most prominent portion of the tuber ischii, the acetabulum will be approximately bisected, the line passing just across the tip of the great trochanter. This is known as Nélaton's line and forms the dividing line between anterior and posterior luxations. If the head lies posterior to this line the condition will be known as a posterior dislocation and the exact position at which the head comes to rest will determine the type of backward luxation present. In like manner anterior dislocations are subdivided according to the point at which the head comes to rest in front of Nélaton's line. The more usual dislocations occurring at the hip may be classified as follows:

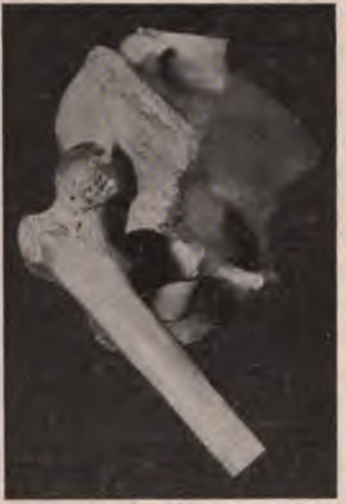

Fig. 576.—High dorsal dislocation of the hip with eversion or outward rotation which is only possible when the outer arm of the Y-ligament is ruptured.

- Posterior luxations
  - Iliac
  - Sciatic
- Anterior luxations
  - Ilio-pectineal
  - Pubic
  - Obturator
  - Perineal

Extreme and unusual conditions sometimes occur but for practical purposes it is inadvisable to attempt their consideration in a classification. In cases of great violence, in which the Y-ligament is torn, the head may lie anywhere in this region and the symptoms accompanying the dislocation will be atypical. The condition may, in rare instances, be compound or complicated by fracture.

Etiology.—Dislocations of the hip constitute from one to two percent of all luxations. They occur most frequently between the fifteenth and forty-fifth years, although they may be seen at any age. The increasing brittleness of the bones as age advances, renders dislocation extremely uncommon in the aged. It occurs about eight times more often in males than in females. Of the various types of displacements, the dorsal iliac is by far the most common. Next in order of frequency is the obturator, a subdivision of the anterior.

Symptoms.—Severe, sickening, localized pain, loss of function, and restricted mobility are symptoms which are common to all forms of dislocation of the hip. Deformity, however, will vary with the position occupied by the displaced femoral head.

In the *iliac type*, the head of the bone lies above and behind the acetabulum, being prevented from occupying a higher position by the restraining action of the untorn ilio-femoral ligament. The thigh is slightly flexed, rotated inward, somewhat adducted, and apparently shortened to the extent of about two inches. The patient's suffering is greatly increased and rigid resistance is felt when passive motion is attempted, especially abduction. A complication of this condition is occasionally observed when the upper posterior portion of the rim of the acetabulum is fractured, and the fragment displaced with the head. Under these circumstances, the head leaves the socket at the point of fracture instead of through the usual rent in the lower part of the capsule. Reduction may be possible by simple traction, since the obstructing portion of the acetabular rim is no longer intact. Crepitus may occur as the serrated surfaces pass, often rendering the condition extremely difficult to differentiate from fracture of the femoral neck. The condition might, more properly, be described as a fracture of the acetabulum, complicated by dislocation. In iliac luxation of the hip there is no tendency towards spontaneous recurrence of deformity following reduction, unless the condition is complicated by fracture of the acetabular rim. In simple dorsal dislocations, passive flexion of the thigh meets with less resistance than motion in any other direction. Loss of function is complete. There are a few reported cases of dorsal dislocation with eversion of the thigh as a result of laceration of the anterior arm of the Y-ligament.

The head of the bone may lie in the sciatic notch, instead of on the dorsum of the ilium, the condition then being known as the sciatic form of posterior dislocation. Under such circumstances, flexion and adduction of the thigh will be more pronounced. We have practically the same dislocation whether the head lies in the sciatic notch, or on the dorsum ilii, the difference being one of degree only. As previously explained, the determining factor between these two types of posterior dislocation, is the obturator internus.

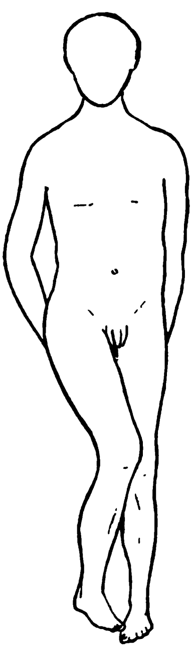

Fig. 577.

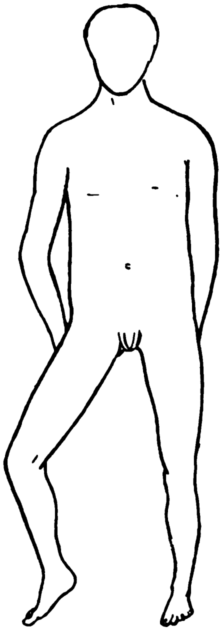

Fig. 578.

Fig. 577.—Attitude in dorsal luxation of the hip. Thigh shortened, adducted and rotated inward.

Fig. 578.—Attitude in anterior luxation of the hip. Thigh lengthened, abducted and rotated outward.

The symptoms in forward dislocation are the same as those just described as far as pain and loss of function are concerned. The deformity, however, is unlike that seen in posterior luxations because of the difference in the positions occupied by the head.

In the ilio-pectineal luxation, the head rests on the horizontal ramus of the pubis, in the region of the ilio-pectineal eminence, in which position it may be palpated. Outward rotation is marked, though abduction and flexion are slight, if present at all. The capsular rent is in the lower or lower anterior portion of the ligament. Numbness and pain may be present along the course of the anterior crural nerve if pressure has been exerted upon it by the displaced head. Pressure upon or injury to the femoral vessels has been observed in some instances. Slight shortening of the lower extremity usually exists, and passive motion, especially inward rotation, meets with solid resistance.

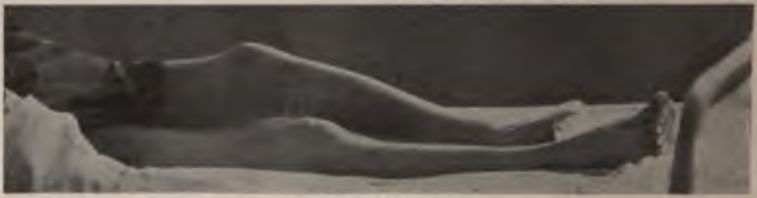

Fig. 579.

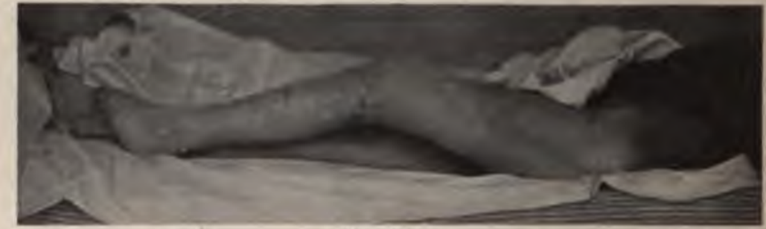

Fig. 580.

Figs. 579 and 580.—Old unreduced dorsal dislocation of left hip of thirty-five years' standing. Patient unable to fully extend thigh though able to get about by the aid of a built-up shoe and cane. Note the shortening, adduction and inward rotation of thigh. The shortening is more pronounced than is usual in recent cases. (Toes of left foot lost through freezing.)

If the head of the bone continues further in its inward course, it may come to rest on the symphysis pubis or above the horizontal ramus, the dislocation then being spoken of as *symphyseal or suprapubic.* These two conditions are but exaggerated forms of the ilio-pectineal luxation, and accordingly the symptoms will be more pronounced and the danger to the anterior crural nerve and femoral vessels is greater. In either of these forms the head of the bone may be felt as a globular prominence somewhere along the horizontal ramus of the pubis.

A few cases have been reported in which the head occupied an extremely high position, directly below the anterior superior iliac spine. This is but a variation of the ilio-pectineal form, and is exceedingly rare.

In the *obturator dislocation,* another form of anterior displacement, the head of the bone fails to ride upward after leaving the acetabulum but comes to rest in the obturator foramen. This form of dislocation is next, in point of frequency, to the iliac type. The limb is slightly flexed, abducted, and rotated outward, and the displaced head may be palpated without difficulty. A depression is noted in the position formerly occupied by the trochanter, the thigh appears lengthened and full extension is not possible.

The *perineal luxation* is simply an exaggeration of the obturator form of displacement, in which the symptoms (especially abduction) are more pronounced. The condition is very unusual. The prominence produced by the head may be recognized both by inspection and palpation. The ischio-pubic rami may be fractured as the head passes across this portion of the pelvis into the perineum.

There is an extremely rare form of downward luxation known as the *infra-cotyloid,* which is analogous to the luxatio erecta occurring in the shoulder. The head of the bone is forced from the acetabulum while the thigh is in extreme flexion, and rests in displacement on the body of the ischium. The thigh is maintained in extreme flexion until the head is replaced. This condition can neither be classed with the anterior, nor with the posterior dislocations, since the head is crossed by Nélaton's line. This luxation is so extremely rare that it might better be considered as a surgical anomaly rather than to describe it as a type.

Another very unusual displacement is known as *central dislocation of the hip,* in which the head is driven through the bottom of the acetabulum. This condition has already been described on page 504 under "Fractures of the Lateral Portions of the Pelvis."

Diagnosis.—The diagnosis is based on the symptoms just described. Recognition of the condition is seldom really difficult, although it is not uncommon to see a dislocation of the hip mistaken for fracture of the femoral neck, or even confounded with some forms of pelvic fracture. The fact that the usual impacted fracture of the neck of the femur should not be broken up, renders it essential that the surgeon be at least reasonably sure of the existing conditions before an attempt is made at the reduction of a luxated hip. In fracture of the neck with impaction, the lower extremity lies in a helpless attitude, shows some shortening and slight outward rotation. There is no abnormal fixation of the parts aside from that produced by reflex muscular spasm. Inward rotation is extremely rare in fracture of the femoral neck. The most common dislocation of the hip is the dorsal, in which adduction and inward rotation are pronounced.

The great majority of dislocations are on to the dorsum of the ilium or into the obturator foramen, and the characteristic deformities accompanying these displacements will suggest the condition when the case is first inspected. In dislocations it will usually be possible to palpate the femoral head, which is, of course, impossible in fractures of the neck. In dislocations, mobility at the hip is much restricted in contradistinction to the normal mobility seen in impacted fractures, and the increased mobility occurring in fractures of the unimpacted type. In dislocations crepitus is absent; in fractures it can almost invariably be elicited. Dorsal dislocation with fracture of the acetabular rim, may be quite difficult to differentiate from fracture of the femoral neck. Crepitus may be present in either injury. In the former, motion is restricted as in all uncomplicated dislocations of the hip, while in the latter, it may be restricted or abnormally increased. Reduction of a simple dorsal dislocation is only accomplished by some system of manipulations, such as Bigelow's, while on the other hand, displacement accompanying fracture of the acetabular rim may be reduced without difficulty by simple traction and countertraction, and there is a strong tendency towards spontaneous recurrence of deformity.

In fractures it is almost always possible to rotate the thigh, and with the finger placed on the trochanter, the arc described by the femoral neck can be ascertained and compared with the uninjured side, and the surgeon can estimate whether or not the center of this arc is in the acetabulum. In dislocations the fixity of the thigh precludes anything but the slightest rotation. When doubt exists as to the nature of the injury the X-ray should be employed to clear up the diagnosis.

Treatment.—The first indication of treatment is the reduction of the displaced head. The method of accomplishing this purpose must, of necessity, vary with the type of dislocation present. The object in all instances is to cause the head to retrace the course taken by it in leaving the cavity. All manipulations must be performed with due appreciation of the strength and attachments of the ilio-femoral ligament (see "Anatomy," page 516). It should be distinctly understood that the common, dorsal dislocation cannot be dragged back into position by simple traction and countertraction without the employment of excessive and unnecessary force and rupture of the ilio-femoral ligament. Reduction must be accomplished by manipulation.

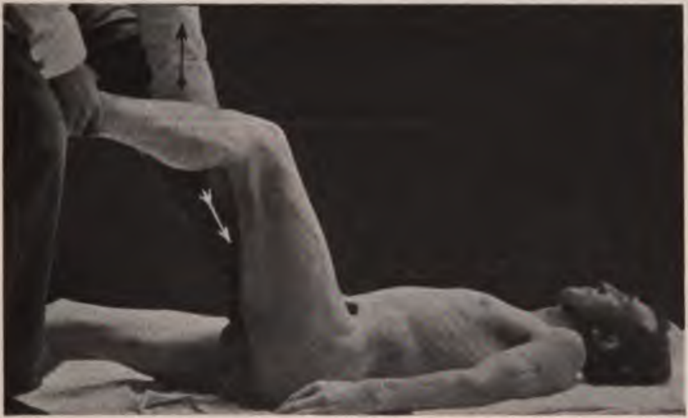

Fig. 581.—Reduction of the common backward dislocation of the hip (see text). In Bigelow's method the thigh is flexed to a right angle, adducted, rotated inward, *lifted*, circumducted outward and extended. The lifting of the thigh is the essential step in the reduction of backward dislocations and may be aided by counter-pressure with the unbooted foot as shown in this plate. In Bigelow's method of reducing anterior luxations the thigh is flexed to a right angle (as shown in this illustration), abducted, rotated inward, adducted and extended. This modification is readily understood if the position of the head in anterior luxations is kept in mind.

In *reducing a dorsal dislocation*, the first step consists in flexing the thigh to a right angle, which move relaxes the Y-ligament. Traction is then made in the line of the axis of the semi-flexed femur, which draws the head of the bone up on to and over the acetabular rim. Outward rotation is then performed, and the thigh allowed to gradually assume the horizontal, or extended position. The head of the bone should slip back into the socket as outward rotation is commenced, or during the first part of extension. The most essential part of this manipulation (Bigelow's method) consists in drawing the femoral head forward from the dorsum of the ilium over the acetabular rim.

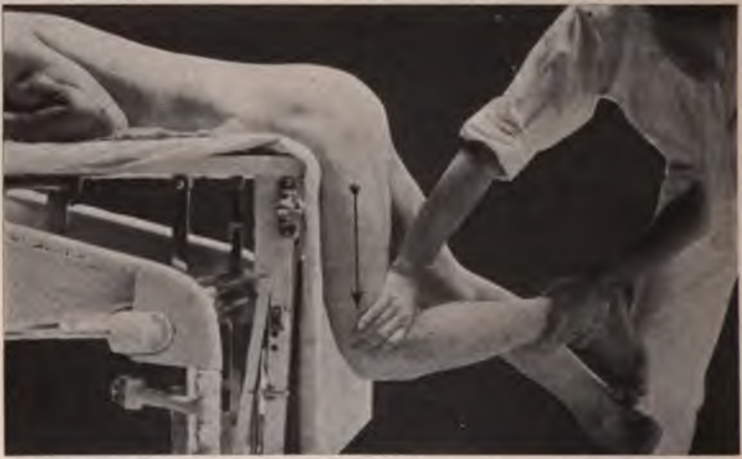

Fig. 582.—Stimson's method of reducing posterior luxations. The weight of the lower extremity pulls in the direction indicated by the arrow and this alone may be sufficient to effect reduction. Downward pressure, however, with the hand, as shown, will render the method more certain. (See text.)

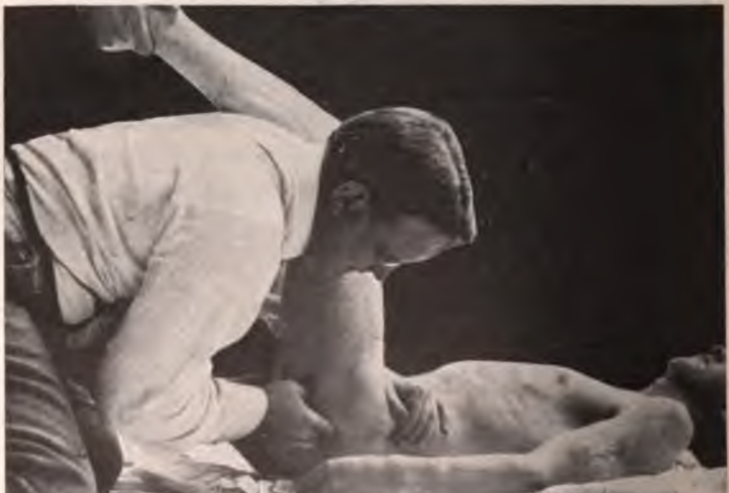

Fig. 583.—Author's modification of Bigelow's method. The thigh is "lifted" (raised sky-ward) by the surgeon's shoulder while counter-pressure is exerted on the anterior-superior iliac spine. The opposite hand exerts direct pressure on the trochanter and prevents it from riding around the rim of the acetabulum. (See text.) It has been the author's experience that difficult cases may be handled in this way after the unmodified Bigelow's method has failed. An anesthetic is often essential to the reduction of dislocations of the hip, especially in well-muscled persons.

The author has found the following original method of accomplishing this result successful in instances in which the above manipulation failed. With the hip and knee flexed at right angles the surgeon places his shoulder under the bend of the knee, one hand is placed on the anterior superior iliac spine, while the opposite hand grasps the trochanter, and exerts pressure in the desired direction. In this position forward traction is made by raising the shoulder, direct manipulation is had by the hand on the trochanter, while counter-traction is exerted through the hand resting on the iliac spine. During this manipulation an assistant should securely hold the patient's ankle, thus fixing the lower leg. According to instructions issued by the surgeon to his assistant during manipulation the ankle may be carried away from, or toward the median plane, thus producing inward or outward rotation of the thigh as desired. In this way the head may be controlled, and forced up on to the slope of the acetabulum, rather than allowing it to ride about the margins of the rim. (See Fig. 583.) No originality is claimed for the principles involved in this manipulation since it is only a modification of Bigelow's method. When, however, difficulty is experienced in forcing the head of the femur over the rim of the acetabulum this manipulation will be found much more efficient than the regular Bigelow's method.

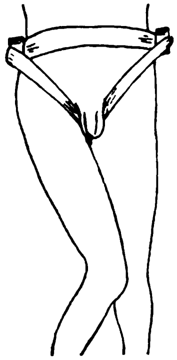

Fig. 584.—Allis' method of securing the pelvis to the floor while reducing luxations of the hip. Three staples are driven into the floor and the pelvis secured as shown.

Stimson's method is as follows: The patient is placed face downward on a table. The injured thigh is allowed to hang over the edge of the table at a right angle, while the uninjured extremity is maintained in the horizontal position by an assistant to steady the pelvis. The surgeon then flexes the knee, and the weight of the knee, with the muscles relaxed, is said to be sufficient to effect reduction. Slight rotation and downward traction will assist in accomplishing the return of the head to the acetabulum. This method works nicely in some cases, though it is by no means as efficient as Stimson's method of effecting reduction in dislocations of the shoulder.

All of the above methods are based on the same principles: namely, bringing the head opposite the capsular rent by flexion and rotation of the thigh, and then forcing the head over the acetabular rim and through the capsular rent by traction in the line of the axis of the femur.

Allis fully appreciated the value of fixation of the pelvis and advises having it secured to the floor by means of a system of screw eyes and bandages (see Fig. 584) or else by means of assistants. This however will not be necessary if the author's modification of Bigelow's method is employed.

The *reduction of anterior displacements* is accomplished by the same principles as already described, although the difference in the position of the head will necessitate different manipulations to bring the head opposite the capsular rent.

The *ilio-pectineal dislocation* and its variations along the horizontal ramus of the pubis are reduced as follows: extension is made to bring the head downward as far as possible so that flexion can be accomplished. The thigh is then flexed at a right angle with the body, while direct pressure is made upon the head to prevent its slipping upward. Inward rotation and traction in the line of the axis of the femur are then performed to return the head to the socket. The last step in this manipulation is similar to that already described under dorsal dislocations.

The *obturator dislocation* and its exaggerated form, the perineal type, are reduced in much the same manner as dorsal dislocations after the head has been brought opposite the capsular rim. The steps are: flexion of the thigh to a right angle, traction in the line of the axis of the femur, and then, abduction and outward rotation. The limb is then extended.

Central dislocations of the hip are reduced by outward traction on the upper end of the thigh while the knee is fixed. The condition is more properly a fracture than a dislocation. Buck's extension is indicated for from six to eight weeks and direct outward traction on the upper portion of the thigh should be maintained, according to the Ruth-Maxwell method, to prevent the muscles attached to the upper femur from pulling the head through the acetabulum into the pelvis. (See "Ruth-Maxwell method," page 545.)

The strength of the muscles and the pain accompanying manipulations renders an anesthetic essential in the reduction of hip dislocations.

Operative Treatment.—Nearly all dislocations of the hip can be reduced by proper manipulation under anesthesia, though occasionally it is impossible to return the head to the socket, unless recourse is had to operative methods. A vertical incision in the region of the trochanter can be so made as to expose the parts involved. When inward rotation is present the incision should be made a little behind the trochanter; when outward rotation is present the incision should be anterior to the trochanter to properly expose the head and neck. With the parts opened, the capsular rent and the course taken by the head after leaving the cavity of the acetabulum may be readily recognized, and by the proper manipulation, the head may be made to retrace its course back to the socket. Obstructions to reduction are to be removed when present. With the head again in the acetabulum, the capsular rent should be sutured, muscular structures approximated and the skin incision closed.

Old, unreduced dislocations are the ones most frequently demanding operative reduction. When the head of the bone has been out of the socket for some time, fibrous tissue forms about it in such a manner that partial restoration of function results. The action of the thigh, however, is always more or less impaired because, if for no other reason, the upper end of the femur is "off-center" with relation to the muscles of the hip. Partial or complete healing of the capsular rent often renders it impossible to accomplish reduction by simple manipulation. If some months have elapsed since the accident the acetabulum may become filled with fibrous tissue, which must be removed with a heavy curette or chisel before the head of the bone can be made to fit it. The joint is approached through a lateral, vertical incision, as already described, which varies somewhat with the type of dislocation present.

Contractures in the thigh muscles sometimes necessitate transverse cutting of either tendons or muscles before the head of the bone can be returned to the socket.

After-Treatment.—Following reduction of a recent dislocation the patient should be kept at rest in bed for a period of from two to four weeks, according to the age of the individual and the severity of the condition. Massage and passive motion are of service in maintaining the muscular tone of the lower extremity. In the performance of passive motion, however, abduction should be avoided, since this is the position in which the head probably left the cavity. Central dislocations and dorsal dislocations complicated by fracture of the acetabular ring require Buck's extension apparatus to maintain reduction. In addition central dislocation calls for lateral traction of the thigh. These appliances should be kept in use for a period of six weeks. During the after-treatment the weights employed in the traction apparatuses may be reduced as the muscular spasm grows less. The resumption of function should be gradual after the patient has recovered sufficiently to leave his bed. He should be instructed to particularly avoid any position of the thigh similar to the attitude in which dislocation occurred.

Prognosis.—The outlook in uncomplicated dislocations of the hip is good if reduction is accomplished early and sufficient time allowed for the repair of the parts before function is resumed. Central dislocation of the hip is a much more serious condition, since it includes fracture of the pelvis and may be accompanied by injury to the pelvic viscera. Proper operative procedures are usually followed by improvement of function, though it is seldom possible to secure a perfect restoration, if the head of the bone has been out of the socket for any considerable length of time.

CHAPTER XXXVII.

FRACTURES OF THE UPPER END OF THE FEMUR.

Surgical Anatomy.—The upper end of the femur has three accessory centers of ossification; one for the head, one for the greater, and one for the lesser trochanter. They all join the diaphysis at about the eighteenth year. Epiphyseal separations, however, are extremely rare in the upper end of this bone, except as a chronic condition in children, which is known as coxa vara. (See "Injuries to the Femoral Neck in Children," page 555.) The structure of the upper end of the femur, including the relation of compact and cancellous tissue, is of importance in explaining many of the clinical conditions occurring in fractures (see Figs. 585 and 586). The upper end of the bone is composed of wide-meshed cancellated tissue, enclosed in a layer of compact structure which grows heavier as the shaft is approached. Closer examination of the cancellous tissue shows that it is disposed in two sets of planes, the socalled "tension planes" and "pressure planes." The former run upward from the outer portion of the shaft into the trochanter, and arch over into the neck and head; the latter ascend from the

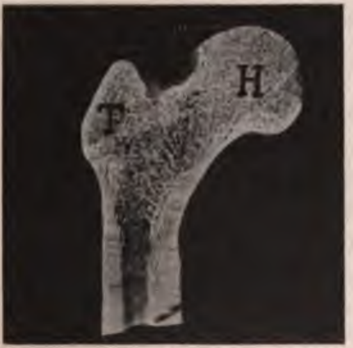

Fig. 585.

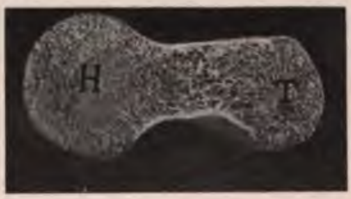

Fig. 586.

Figs. 585 and 586.—Coronal and nearly horizontal sections of the upper end of the femur showing the relative distribution of cancellous and compact tissue. *H.*, head of femur. *T.*, trochanter major. (Preston—*Surg., Gynecol. and Obstet.*, Feb., 1914.)

inner side of the shaft and pass into the head, while others arch over to the great trochanter. These planes are simply an arrangement of the cancellous tissue which renders the same amount of bone more capable of withstanding the pressure and tension to which the femur is subjected by use. The calcar femorale is a thickening in the internal structure of the neck which strengthens the angle of junction between neck and shaft.

The neck joins the shaft at an angle of about 127 degrees, although variations occur between the limits of 121 and 144 degrees. In children the angle is more obtuse, while in old age it approaches the right angle. The great trochanter is often traversed by a continuation of the compact tissue of the posterior surface of the neck, and although this tends to strengthen the posterior aspect of the neck, yet the arrangement is not as strong as that found anteriorly.

Numerous muscles are attached to the upper end of this bone, which influence the relative positions of the fragments in the presence of unimpacted fracture of the neck. Raising of the lower fragment or, in other words, shortening of the lower extremity, is brought about by the action of the ham-string muscles, the adductor group, the glutei, rectus, sartorius, ilio-psoas, tensor vaginæ femoris, pectineus and gracilis. Eversion of the lower extremity is the result of the weight of the thigh, the center of gravity being external to the articulation of the hip. Eversion, in impacted cases, is due to the manner in which the base of the neck is driven into the trochanter and the fact that the anterior portion of the femoral neck is stronger than the posterior. In addition to the action of the pectineus and the adductor muscles, it will be observed that all the glutei tend to produce outward rotation.

Fractures may occur in the neck, close to the head, midway between the head and the great trochanter, or at the base of the neck where it joins the shaft. The last named position is by far the most common. In some instances the fracture may pass in such a manner that it involves the upper portion of the femoral shaft as well as the neck. Fractures have been divided anatomically according to the position of the break with relation to the capsule. Intra-capsular fractures show a much stronger tendency toward non-union than those outside the capsule. Surgically, however, this distinction is not of great value, since it is almost impossible in a given case to say whether the fracture is within or outside of the ligament. Moreover, post-mortem findings have demonstrated the fact that in the majority of instances in which the neck is broken, the line of fracture is both intra- and extra-capsular; that is, the fracture passes through the femoral attachment of the ligament. The more practical distinction is whether or not the fracture is impacted. Impaction consists, as a rule, in the base of the neck being driven into the substance of the great trochanter. If the neck is viewed from above one reason for the frequency with which eversion accompanies impaction will be apparent. The anterior surface of the neck is almost straight and flush with the front edge of the trochanter, thus offering solid support to the anterior portion of the trochanter in the presence of direct violence. The posterior surface of the neck is much curved and does not come flush with the posterior margin of the trochanter. This results in the posterior portion of the trochanter being much more poorly supported than is the anterior, and when direct violence is applied in this region of the bone the posterior aspect of the neck will be more likely to give way than the anterior. The result is, manifestly, eversion when impaction of the femoral neck occurs. The continuation of the compact tissue of the posterior surface of the neck into the trochanter, previously mentioned, tends to strengthen this portion of the bone; yet this bony tissue is variable and even when present is not sufficiently heavy to increase the strength of the posterior aspect of the femoral neck so that it equals that found in the anterior portion. When the ring of compact tissue surrounding the junction of the neck and shaft is fractured, the neck crushes into the cancellous tissue of the trochanter with comparatively little resistance.

The surgeon should know the bony landmarks in this region to be able to properly diagnose and treat fractures of the femoral neck. The crest of the ilium is subcutaneous throughout, the great trochanter can be recognized both by inspection and palpation, and the tuberosity of the ischium can be readily felt. The relative positions of the anterior superior iliac spine, tuber ischii and trochanter major should be known under normal conditions in order that the variations occurring in fractures may be recognized. If a tape is stretched between the anterior superior iliac spine and the tuberosity of the ischium it will correspond to Nélaton's line (see Fig. 587). Normally Nélaton's line about touches the top of the great trochanter. In fracture of the femoral neck with shortening, the top of the trochanter rises above this line. The fascia lata, composed of heavy fibrous tissue, is attached above to the outer lip of the iliac crest, and below to the external tuberosity of the tibia. Under normal conditions this fascia is tense and offers resistance when pressure is made between the iliac crest and trochanter; when fracture or disease of the femoral neck results in shortening, this portion of the fascia lata becomes lax, which condition may be recognized by comparison with the opposite side.

The rarifying changes or osteoporosis occurring in old age affect the entire internal structure of the upper end of the femur, and tend to remove the calcar femorale, and the extension of the posterior surface of the neck which continues into the substance of the trochanter. In addition, the surface compact tissue becomes thinner and more brittle. These changes together with the alteration in the angle at which the neck joins the shaft explain, at least partially, the frequency of fracture of the femoral neck in the aged.

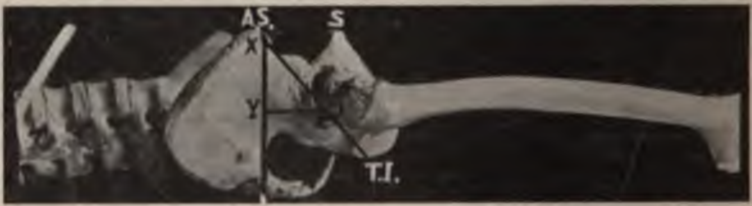

Fig. 587.—Mapping out of Bryant's triangle and Nélaton's line. A line drawn from the anterior superior iliac spine to the tuberosity of the ischium is known as Nélaton's line and should about touch the top of the great trochanter. (See Fig. 600.) A vertical line dropped from the anterior superior iliac spine to the table on which the patient lies and a vertical line extended upward from the top of the great trochanter form two sides of Bryant's triangle while the third side is formed by Nélaton's line. Bryant's' triangle—*X.Y.Z.* In fractures of the femoral neck the distance *Y.Z.* is usually shortened. *A.S.*, the anterior superior iliac spine. *S.*, Symphysis pubis. *T.I.*, Tuber ischii.

Fracture of the head of the femur is an extremely unusual condition, only two or three cases having been reported. It is not an uncommon matter for fractures of the neck of the femur to involve the great trochanter, but isolated fracture of the trochanter is almost as rare as fracture of the head. The cases reported have been due either to direct violence or to muscular action. Isolated fracture of the lesser trochanter is also a rare condition. The reported cases seem to have been due to the action of the ilio-psoas.

Etiology.—Fracture of the neck of the femur is essentially an accident of advanced life. Fractures of the femur constitute

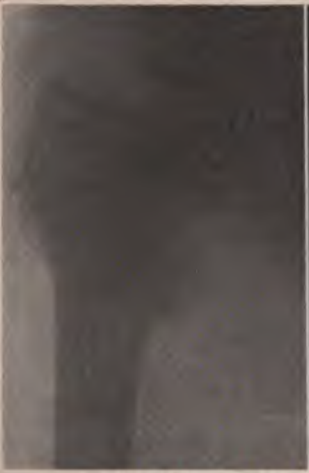
Fig. 588.

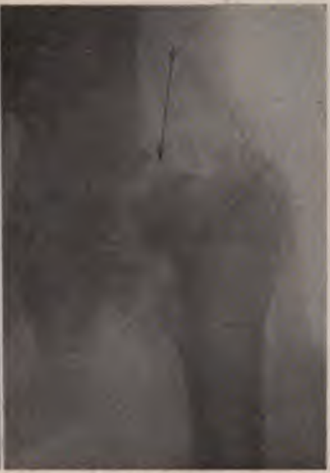
Fig. 589.

Fig. 588.—Impacted fracture of base of femoral neck.

Fig. 589.—Old ununited fracture of middle of femoral neck with upward displacement of lower fragment. The upward displacement of the femur is plainly visible and the manner in which the fascia lata becomes lax between the trochanter and iliac crest is readily appreciated.

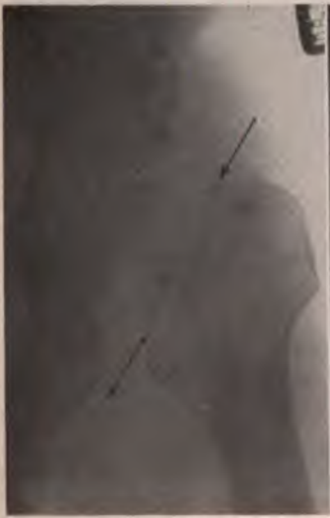
Fig. 590.

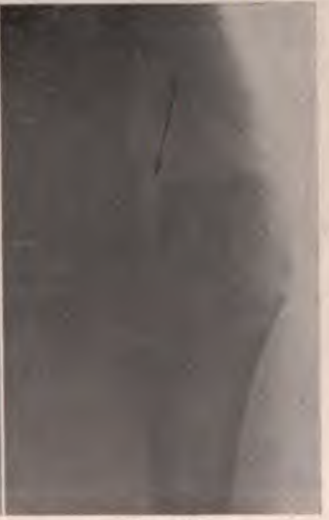
Fig. 591.

Fig. 590.—Impacted fracture of neck of femur.

Fig. 591.—Fracture of femoral neck with usual deformity—raising of trochanter.

Fig. 592.

Fig. 593.

Fig. 592.—Fracture of rim of acetabulum. Upper arrow points to line of fracture while the lower indicates the detached fragment. Deformity controlled by Buck's extension.

Fig. 593.—Fracture of a small portion of the great trochanter with separation of the fragment. Result of muscular action. A condition which might readily be overlooked and considered as a "sprain" if the X-ray were not employed.

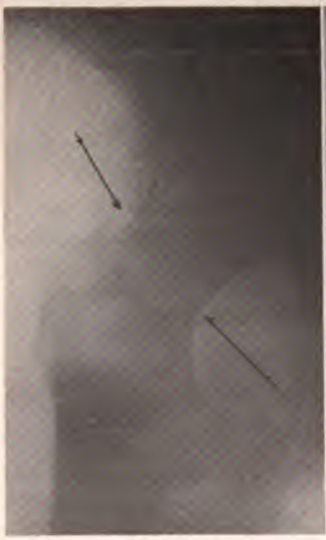

Fig. 594.

Fig. 595.

Fig. 594.—Fracture through femoral neck about midway between head and trochanter. Deformity overcome by Buck's extension.

Fig. 595.—Fracture through base of femoral neck with splitting off of lesser trochanter.

about six percent of all fractures, and fractures of the neck of the bone make up from one-third to one-fourth of all femoral fractures. More than half of the fractures of the neck occur after the sixtieth year. They are more common in women than in men.

Symptoms.—The physical signs and symptoms in fracture of the femoral neck vary according to whether or not impaction exists. In the unimpacted form the patient is unable to stand on the injured member. In fact the lower extremity lies in an entirely helpless attitude. Pain is constant, and increased on motion. The limb is usually completely everted so that the outer surface of the foot rests flat on the bed. The great trochanter is raised above Nélaton's line, and the fascia lata between the trochanter and iliac crest is found relaxed when compared with the opposite side. Inversion of the limb, though extremely rare, may be present, instead of eversion. Crepitus and mobility may be elicited, but all manipulation should be most gentle and guarded, lest impaction, if present, be broken up. Rotation is particularly likely to loosen the impaction. The limb is shortened, though seldom more than two inches. The shortening is usually less pronounced immediately following the accident than it is at the end of twenty-four or forty-eight hours. Traction upon the foot lessens the shortening, though recurrence is prompt when the foot is released. A slight fullness in the upper portion of Scarpa's triangle is usually noted.

When the fracture is impacted most of the above described symptoms are present though less pronounced. Slight or moderate eversion is usually noted, and some shortening exists though it is by no means as great as is commonly seen in unimpacted cases. Crepitus is absent. Pain is usually present, though the degree is quite variable. Loss of function is by no means as constant and pronounced as in unimpacted fractures. In fact, a patient with a firmly impacted fracture of the femoral neck may be able to walk a considerable distance. This incomplete loss of function has not infrequently been the cause of incorrect diagnoses, the condition having been mistaken for a "sprain." Impaction of the fracture produces some shortening of the femoral neck, which may sometimes be recognized in the shorter arc described by the trochanter when the thigh is rotated. This shortening, however, is often so slight that it is difficult of recognition, and since rotation is so likely to break up impaction it will usually be best to pass lightly over this symptom. The history given in the usual case of frac-

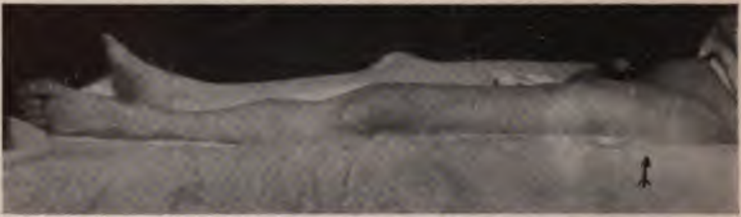

Fig. 596.—Impacted fracture of the femoral neck. Very slight degree of shortening present and eversion is only moderate.

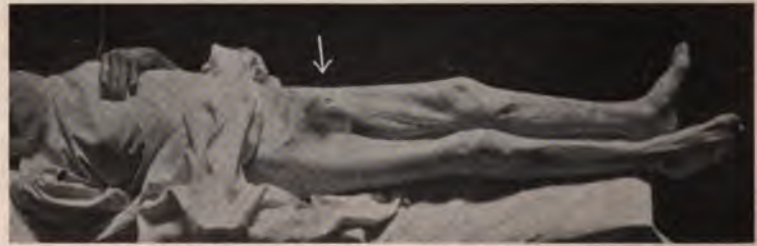

Fig. 597.—Impacted fracture of the neck of the femur in an old man. The limb is helpless. Very slight eversion and shortening present. There is no appearance of twisting of the thigh as seen in Fig. 626, nor is there any thickening of the thigh as seen in Fig. 598. Röntgenogram shows fracture of the femoral neck. It is this type of case which is so often overlooked and diagnosed as a "sprain" especially if the patient is able to walk.

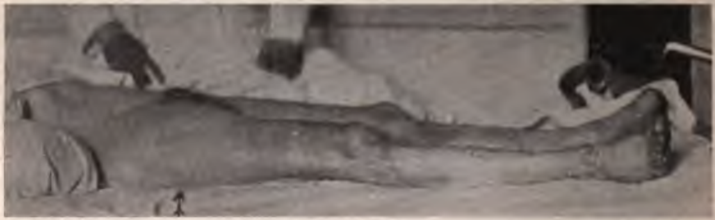

Fig. 598.—Fracture of right femur through great trochanter. Note thickening of the thigh in its upper part and the eversion of the lower extremity. Compare the levels of the two knees which are directly in front of the camera. Right thigh slightly shorter. Picture taken a few minutes following the injury.

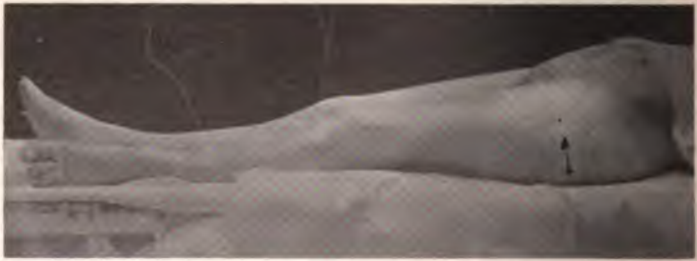

Fig. 599.—Fracture just below the great trochanter. Note the eversion and shortening.

ture of the femoral neck in elderly persons is one of slight trauma, such as a misstep, a twist of the thigh, or a fall in walking across the room. It is sometimes difficult to ascertain whether the fall produced the fracture, or whether the fracture was spontaneous and resulted in the fall.

Diagnosis.—The deep position of the femoral neck, surrounded by heavy muscles and fasciæ renders palpation of this portion of the bone extremely difficult. The diagnosis is based on the symptoms just described, together with a careful examination of the lower extremity including mensuration and comparison with the uninjured member. The X-ray is invaluable in diagnosticating the presence of fracture; in fact it is the only means of determining accurately the details of the injury.

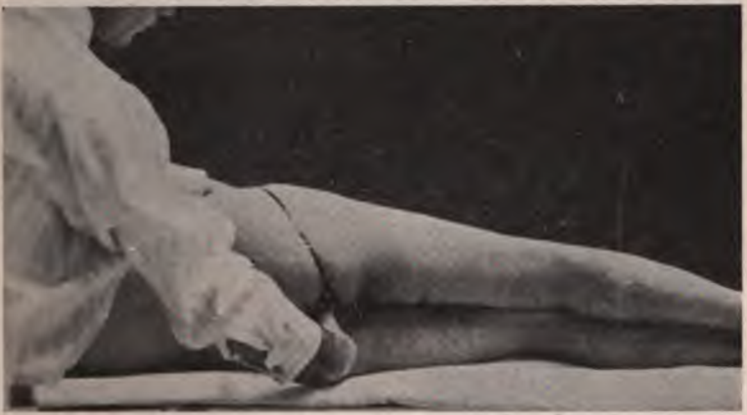

Fig. 600.—Drawing a line between the anterior superior iliac spine and the tuberosity of the ischium to determine the relative level of the greater tuberosity. Nélaton's line. (See Fig. 587.)

Nélaton's line and Bryant's triangle (see Fig. 587), should be mapped out and the position of the trochanter determined with relation to the bony landmarks of the pelvis. (See "Anatomy," page 533.) The case should be carefully inspected for the purpose of recognizing deformity, and accurate measurements should be made before manipulation in any form is attempted. The distance from the anterior superior iliac spine to the tubercle of the femur, and then to the internal malleolus should be taken with a steel tape, and compared with the distances between the corresponding bony prominences of the opposite lower extremity. In taking these measurements the patient should be placed squarely in bed so that a line drawn through the anterior superior iliac spines will be at right angles to the spinal column. In other words the pelvis should not be "tipped" at the time the measurements are being taken.

Fracture of the femoral neck must be differentiated from dislocations of the hip, fracture of the acetabulum with or without displacement of the head, fracture of the pelvis, and fracture of the femoral shaft.

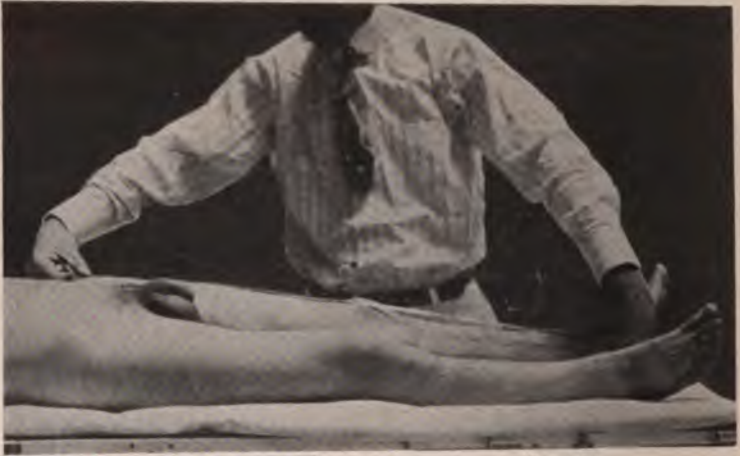

Fig. 601.

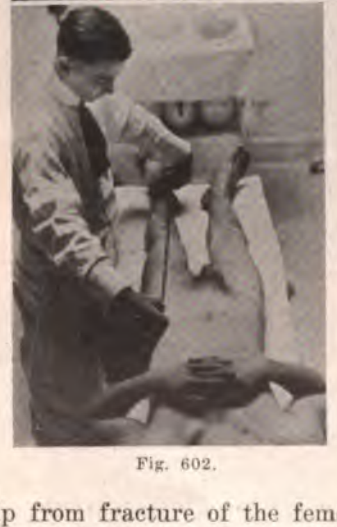

Fig. 602.

Fig. 601 and 602.—Measuring the length of the lower extremity from the anterior superior iliac spine to the tip of the internal malleolus. The legs should be parallel and the pelvis should not be tipped. In other words a line drawn through the anterior superior iliac spines should be at right angles with the median plane of the body. (See Figs. 603 and 604.)

The characteristic attitude assumed in luxations of the femoral head, the restricted mobility and, in some instances, direct palpation of the displaced head, should serve to distinguish dislocations of the hip from fracture of the femoral neck. In fractures of the femoral shaft the position occupied by the great trochanter will be found normal and the point of preternatural mobility will be located below it. When the thigh is rotated the trochanter will fail to follow the shaft. Fracture of the acetabular ring and certain pelvic fractures are occasionally difficult to differentiate from fracture of the femoral neck unless a Röntgenogram is made. In fact the X-ray should be employed in almost all injuries about the hip. Inspection, palpation and mensuration may enable one to determine the seat of the lesion but it is impossible to ascertain the exact details and nature of the fracture without the aid of an X-ray plate. Moreover one cannot be sure, prior to examination, whether or not impaction exists, and it is much better to refrain from manipulation altogether, rather than to break up an impaction. The surgeon who is unaccustomed to dealing with these

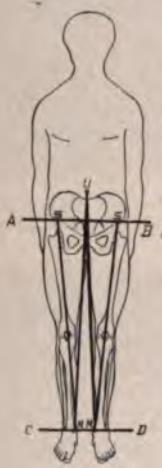

Fig. 603.

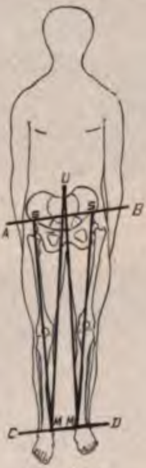

Fig. 604.

Fig. 603.—Measurements of the lower extremities taken with the legs parallel and the pelvis up-tipped.

Fig. 604.—Shows the effect of tipping the pelvis when these measurements are being taken.

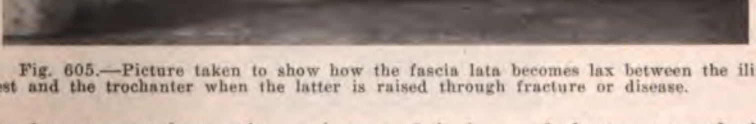

Fig. 605.—Picture taken to show how the fascia lata becomes lax between the iliac crest and the trochanter when the latter is raised through fracture or disease.

cases had better submit the patient to an X-ray examination before any extensive manipulation is attempted.

Treatment.—The treatment of fracture of the neck of the femur depends, first on the age and condition of the patient, and next on whether or not the fracture is impacted. As far as the fracture itself is concerned, recumbency is a prime requisite, but the fact that old persons are unable to stand prolonged confinement to bed, makes it necessary to adopt some form of ambulatory treatment or one in which the patient may be raised to the sitting position. When the neck of the femur is fractured in elderly persons the treatment is often more a question of the prevention of complications, such as hypostatic pneumonia, than complete restoration of function in the injured member.

There are at the present time four recognized methods of treating fractures of the hip. They are: *recumbency with traction and counter-traction*, *the plaster cast*, *the ambulatory splint* and *open treatment*. Each form of treatment has its modifications, and combinations of these methods are not uncommon in the treatment of fractures of the femoral neck. None of them is ideal; they all have their advantages and their drawbacks. Each case should be carefully considered and the method or combinations of methods best suited to the case in hand should be adopted. In selecting the mode of procedure to be followed the surgeon must consider his surroundings and the available facilities as well as the age and condition of the patient.

If the patient is strong enough to remain in bed during the process of repair the fracture may be treated by Buck's extension and the long side splint. It is essential that the bed be firm and unsagging. If a fracture bed cannot be obtained the ordinary bed may be made more rigid by placing boards under the mattress to prevent sagging. Buck's extension is applied as shown in Figs. 606 and 607. The lower extremity is soaped, shaved, sponged with alcohol and thoroughly dried before the adhesive plaster is applied. The wooden spreader below the foot should be broad enough to keep the adhesive plaster from touching and irritating the ankles. The weights employed should be sufficient to control the muscular spasm and will vary with the build of the patient. Greater weight will be required during the first day or two than is necessary later when the muscles have been tired out by the continuous pull of the extension apparatus. From ten

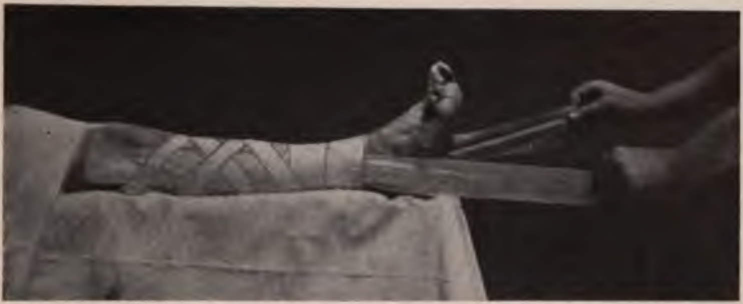

Fig. 606.—Shows adhesive plaster applied to the leg to secure longitudinal traction on the lower extremity. Buck's extension.

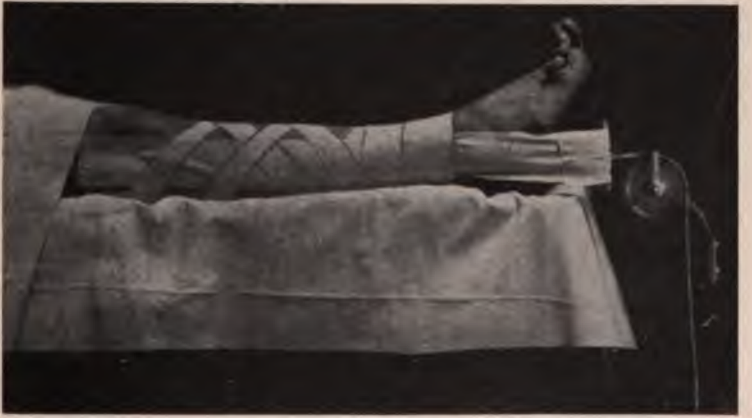

Fig. 607.—Shows Buck's extension completed. The strips of adhesive have been fastened to the spreader, and rope pulley and weight attached. The spreader consists of a small square piece of light board with a hole drilled through its middle for the attachment of a light rope. Its purpose is to prevent the adhesive plaster from coming in contact with the skin over the malleoli and to act as an equalizer so that the pull will be the same on both strips of adhesive. (See page 542.)

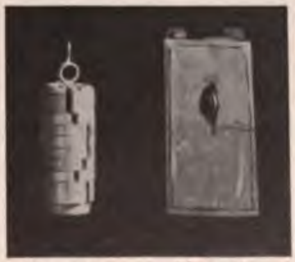

Fig. 608. Fig. 609.

Fig. 608.—A convenient form of weight to be used with Buck's extension.

Fig. 609.—A good adaptation of the pulley to be attached to the foot of an iron bed.

to twenty pounds may be advisable during the first few days, but later in the treatment six or eight pounds will usually be all that is necessary to steady the parts and overcome the increased muscular tone. The patient will be more comfortable with a proper weight than with too much or too little. Counter-extension is obtained by raising the foot of the bed eight, ten or even fifteen inches, according to the weight used. With the extension apparatus in place a long side splint is applied, the upper end extends to the eighth or tenth rib and is secured to the trunk by means of a body swathe. The thigh and leg are secured to the splint by means of bandages or adhesive plaster. If a cross-piece is attached to the lower end of the splint it will render the whole more steady and secure. In unimpacted cases particular care should be taken to correct eversion. This can be nicely accomplished by transverse strips of adhesive passing under the thigh and over the side splint

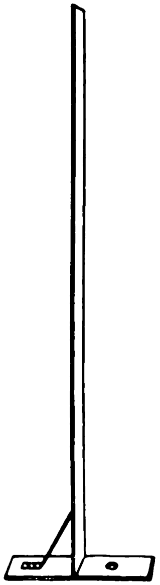

Fig. 610.

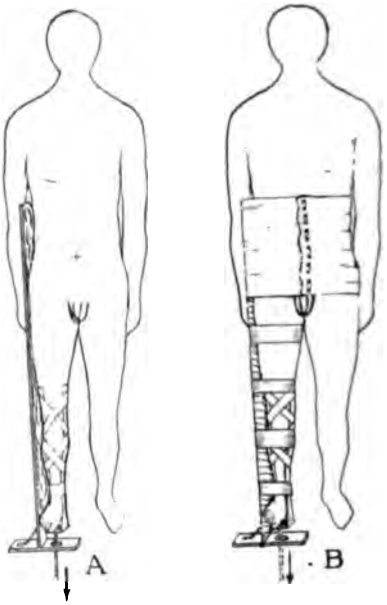

Fig 611.

Fig. 610. Long T splint used in the treatment of fractures of the neck or shaft of the femur. A strip of wood about one foot in length may be nailed in the angle of the splint to prevent the bed clothes resting on the foot. This will obviate the necessity of using a cradle. (See Fig. 708.)

Fig. 611. *A* shows Buck's extension applied and T splint in position with appropriate padding. *B* shows the padding bandaged to the splint and the latter secured in position by means of strips of adhesive and body swathe.

to which they are fastened. If the fracture is impacted, extension and counter-extension should be applied with caution lest the impaction be broken up. Enough weight, however, should be used to control the muscular spasm which is capable, in some cases, of breaking up the impaction, if not counteracted by the extension apparatus. Sand bags on either side of the limb may be used to advantage instead of the splint, especially in impacted cases. Extension and counter-extension is one of the oldest methods of treating fracture of the hip. The fixation secured in this manner is not as perfect as that obtained by the plaster cast or by one of the metal splints to be described later; yet excellent results have followed its use. This method is particularly serviceable during the first week or ten days following the accident. It is often advisable to substitute some other form of fixation (such as the brace or cast) after the acute inflammatory reaction at the site of fracture has subsided, and the shortening has been partially or completely overcome by the extension apparatus. During this initial period one can determine by palpation, mensuration and the X-ray the degree of reduction which has been accomplished by non-operative measures and the advisability of resorting to open treatment.

The Ruth-Maxwell method is an elaboration of the above in which lateral traction is exerted on the upper end of the femur in addition to longitudinal extension and counter-extension. The longitudinal traction is accomplished as already described. The outward traction on the upper end of the femur is had by means of a sling passed about the thigh at the level of the perineum, and then by the use of a cord, pulley and weight; outward and forward traction is exerted, as shown in Fig. 612. Counter-extension for this lateral traction is obtained by raising the same side of the bed a few inches. In unimpacted cases the lateral traction may be made to overcome the backward displacement of the upper end of the lower fragment. Eversion of the lower extremity can be corrected by placing most of the pull on the posterior arm of the sling about the thigh. When used in this way the sling should be prevented from slipping about the thigh by securing it to the skin with adhesive. A number of advantages are claimed for this method: firstly, that the neck is maintained at a more nearly normal angle during the process of repair, secondly, that the patient may be raised to the sitting position without disturbing the fragments, and thirdly, that the use of the bed-pan is greatly facilitated.

The advisability of employing this method is best determined in a given case, by ascertaining the degree of reduction which it accomplishes as shown by palpation, mensuration and the X-ray. If in an unimpacted case the apposition is improved by lateral traction, this method is indicated.

The plaster cast has been used with considerable satisfaction and may be varied to meet the needs of the case. It may be employed in a number of ways; the following three types of cast will be found the most important.

The straight cast is most often employed in middle aged patients; in old and feeble persons the cast is applied with the knee and hip flexed to about right angles so that the patient may be raised to the sitting position during the day; and in children it may be applied with the thigh in extreme abduction according to the principles laid down by Whitman.

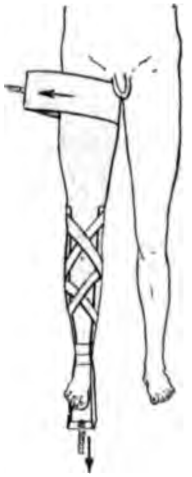

Fig. 612.

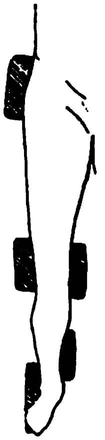

Fig. 613.

Fig. 612. Diagram illustrating the principles employed in the treatment of fractures of the femoral neck according to the Ruth Maxwell method.

Fig. 613. Shows the proper distribution of sand bags to steady the lower extremity when the hip is fractured

The *straight cast* should extend from the waist to the toes and be properly lined with sheet cotton or some other material, to avoid irritation of the skin. If a union suit of soft, ribbed material is put on before the cast is applied we will have a very satisfactory form of lining. After the plaster has set and dried, the portion of the union suit not covered by the cast may be cut away. A stomach pad should be placed between the cast and the abdomen the same as employed with casts of the trunk. Special reënforcements of plaster-soaked gauze, tin, or cypress wood should be used at the groin and behind the knee where the cast most frequently breaks. These reënforcements are best placed between the different layers of the plaster bandages as the cast is being applied. The knee should be in a position a little short of complete extension to avoid subsequent discomfort in the joint. The cast should be heavy enough to stand the strain of the six or eight weeks of use to which it will be put during the after-treatment. This dressing accomplishes fixation very nicely whether recumbent or ambulatory treatment is employed. If used as an ambulatory splint the shoe of the opposite foot should have the sole built up as is commonly done with the Thomas splint. The ambulatory treatment should not be allowed in old persons unless the surgeon is satisfied that the patient is not too feeble to get about with crutches without the risk of further fall and injury. Old and feeble persons do not stand confinement in bed for a period sufficient to obtain union, on the other hand they are often unable to get about with the added en-

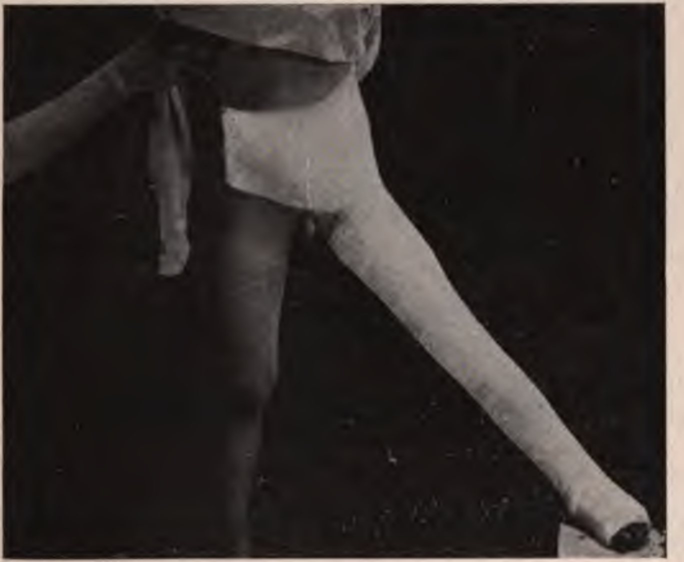

Fig. 614.—Plaster cast for fracture of the hip applied with the thigh in abduction. A strap passing from the body portion of the cast under the perineum will add to the security of the fixation. An even more secure form of cast is one which includes both extremities in abduction.

cumbrance of a hip splint or cast. In such cases the author has had considerable satisfaction with the following original method.

The cast is applied with the hip and the knee flexed at about right angles. In other words the injured member is encased in plaster in the attitude normally assumed when the patient is seated. With the lower extremity in this position the patient can comfortably occupy an easy chair during the day and still rest well in bed at night with the flexed lower extremity properly bolstered. If a Morris chair is employed in the treatment, the movable back may be raised during the day and the foot of the injured member properly supported on a foot stool or pillows. When night comes the back of the chair can be lowered so that the patient resumes the dorsal recumbent position, while the injured leg is raised and supported by pillows, sand bags or some other arrangement. (See Fig. 615.) In this way he may enjoy good rest at night and still be in the sitting position during the day, thus avoiding the development of hypostatic pneumonia. If traction is made at the knee while the plaster is setting a fair degree of extension and counter-extension may be had during the after-treatment. This is made possible by the position of the leg which is at right angles with the thigh.

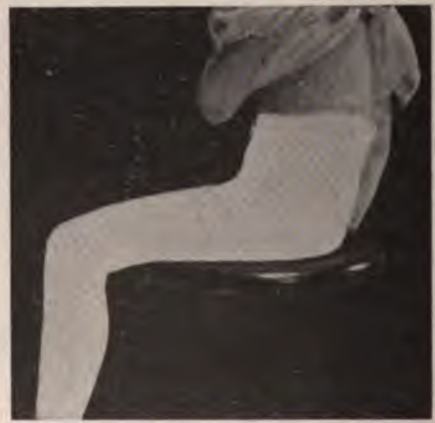

Fig. 615.—Cast of lower extremity and trunk applied with the thigh and leg flexed to right angles. This form of cast is of great advantage when the hip is fractured in elderly persons who are unable to stand the recumbent position. During the day the patient may be placed in the sitting position while at night he may lie on his back with the injured member properly bolstered. (See text.)

The plaster cast may be employed with the thigh in extreme abduction as practiced by Whitman. This method is particularly applicable in children and is based on sound mechanical and anatomical principles. By abducting the thigh the lower portion of the capsular ligament is made tense and the fractured surfaces (if engaged at all) are thus forced firmly together. This position is maintained by means of a plaster of Paris spica of the thigh. In selected cases this method will be productive of excellent results and deserves a more extended trial in adults.

It should never be taken for granted, in a given case, that good reduction has been accomplished because the thigh has been abducted and fixed in this attitude. The position of the fragments should be verified by the X-ray.

The reason that this method has met with such success in children is due firstly, to the fact that fractures of the femoral neck at this period of life are seldom complete, and secondly, that abduction with the fractured surfaces opposed and firmly engaged tends to prevent the subsequent lessening of the angle at which the neck joins the shaft. In other words, it prevents coxa vara. If the fractured surfaces are not engaged this method is valueless.

The Thomas hip splint has been used with considerable success by some surgeons. The main drawback to this splint, and others employing the same materials and principles, consists in the cost and the difficulty of obtaining the services of some one competent to properly make and fit it to the patient at the time it is needed. The surgeon is not, as a rule, equipped for this work which should be done by an experienced blacksmith and leather-worker. In most of the larger cities there are makers of surgical instruments and orthopedic appliances who are thoroughly qualified to produce and fit a satisfactory splint, but in country practice it is often difficult to procure the desired apparatus on short notice.

The splint is made of soft iron and consists of a main stem or bar of 3/16 by 5/8 inch material which extends from the chest to the ankle along the posterior aspect of the trunk and lower extremity. To this main stem is attached a chest-band, a thigh-band and a calf-band as indicated in the accompanying diagram (Fig. 620). These bands are made of strips of soft iron 1/8 by one inch, on cross section, and are bent into position when the splint is applied. Different weights of material may be used according to the size and musculature of the patient, and the transverse encircling bands may be varied in position and number according to the nature of the case and the fixation desired. The main stem of the splint should follow the curves of the body and lower extremity, and the points of junction between main stem and bands should be flush, to avoid undue local pressure and irritation. The entire splint should be well padded and bound with leather and the anterior extremities of the horizontal bands connected by straps and buckles. By means of crutches and a built-up shoe for the opposite foot the patient, after some practice, is able to be up and about. It often requires a number of trials before he becomes sufficiently sure-footed under these awkward circumstances, and the surgeon should see that he is properly attended to prevent falling.

When ambulatory treatment is indicated, as is the case in old persons from the first, and in younger patients during the second half of the after-treatment, the Thomas splint has served well. If extension is required it may be had by means of adhesive strips applied in a manner similar to that shown in the use of Buck's extension (see page 543). The lower ends of the longitudinal strips of adhesive are secured, under tension, to the calf bands of the splint.

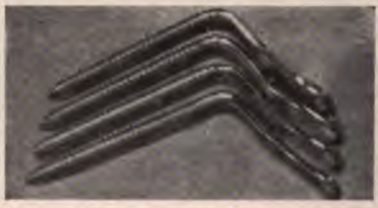

Fig. 616.—Author's screw plates for internal fixation of fractures of the femoral neck. (See Figs. 617, 618 and 619.)

The ambulatory pneumatic splint, as shown in Fig. 621, with the hip attachment, has the advantage of being adjustable, so that it can be used on different cases, and is so constructed that it may be used for either hip. Extension is also provided for when needed (see Fig. 719).

Operative Treatment.—The open method is indicated in non-impacted cases in which the fragments cannot otherwise be brought back into satisfactory apposition. Nailing and pegging the neck in place have been practiced for some years past but, because of the internal structure of the upper end of the femur, the end results have not been as encouraging as might be desired. The cancellous tissue, through which the screw passes, crushes so readily that displacement following the operation is prone to occur. The manner in which this takes place is indicated in Fig. 618. To avoid this result two screws or nails, placed at different angles have been used but the results following this method have been almost as uniformly inefficient as when a single screw is employed. A much more satisfactory method is that devised by the author in which a modified Lane plate is employed, as shown in Fig. 619. By means of this screw-plate the compact tissue below the great trochanter is utilized to prevent the inner end of the screw portion of the appliance from being displaced downward. The head of the bone is thus hung on the end of the screw portion much as a hat is hung on a peg, the plate securing its hold on compact tissue.

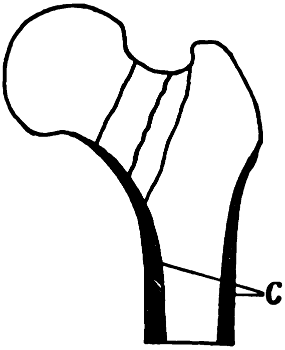

Fig. 617.

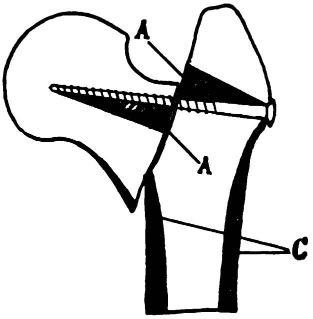

Fig. 618.

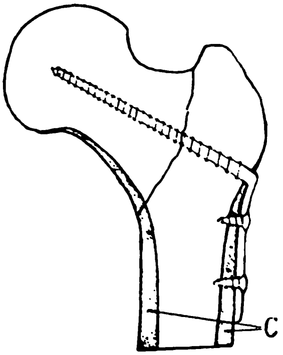

Fig. 619.

Fig. 617.—Diagram of femur showing the common sites of fracture of the femoral neck. (*Surg., Gynecol. and Obstet.*, Feb. 1914.)

Fig. 618.—Diagram showing the manner in which the cancellous tissue crushes when the neck is subjected to the displacing action of the thigh and hip muscles, following operation with a simple screw or nail. (*Surg., Gynecol. and Obstet.*, Feb., 1914.)

Fig. 619.—Diagram showing the author's screw-plate in position. Angulation of the screw portion is prevented by the plate portion which secures a firm hold on the only available compact tissue in this region. (*Surg., Gynecol. and Obstet.*, Feb., 1914.)

Before drilling through the trochanter the surgeon should make sure of the proper alignment of the head and neck. This can usually be accomplished by dull dissection along the neck outside the capsule. Following operation, external fixation apparatus should be employed to relieve the bone of as much strain as possible. Simple extension and counter-extension with the long side splint may be used, or the plaster cast applied. The cast is, as a rule, preferable following operation on the hip or thigh and should be applied before the patient comes out of the anesthetic. Within forty-eight hours of the operation a window should be cut through the plaster to expose the region of incision. In operating on the neck of the femur the parts may be exposed by a vertical incision over the trochanter or an incision of the U-type may be employed.

The best time for operation is at the end of a week or ten days following the accident. When the open method is selected early in the condition because it offers better reduction and apposition of the fractured surfaces the results are usually satisfactory. When, however, operation is performed as a last resort when other methods have resulted in non-union or deformity the results are not nearly as good. In operating for non-union the fibrous tissue must be cut away and the fractured surfaces freshened and secured in apposition, preferably by the screw-plate just described. This procedure necessarily results in some loss of tissue and shortening of the neck. If the fracture is through the inner end of the neck and the head is comminuted, it may be advisable to remove the fragments, round off the end of the femoral neck and rely on the formation of a new articular surface. Remarkably good results have followed resection of the femoral head. Murphy has demonstrated the possibility of making a new femoral head and articular surface from a transplanted portion of the great trochanter, and of reëstablishing the function of the joint following ankylosis. These operations, however, are rarely called for as a result of fracture of the femoral neck. Operative intervention offers little in the aged and is seldom called for in children. It offers most in the healthy adult, and is indicated in cases in which good reduction cannot otherwise be obtained, and in instances in which deformity or non-union with considerable loss of function has followed non-operative methods.

After-Treatment.—The fact that the fragments have been placed in good apposition does not necessarily mean that they will remain so and it should be the surgeon's greatest care during the after-treatment to see that the fixation apparatus employed is properly performing its function. Numerous adjustments will be needed during the process of repair. A weight of fifteen or twenty pounds may be necessary during the first few days but at the end of a week it may be entirely too much. If the patient is confined to bed the back and heels should be watched for signs of skin irritation, and should they develop special care must be taken to keep the parts dry and relieved of pressure. The sheets should be clean, smooth and free from wrinkles and the patient should be frequently sponged and rubbed with alcohol especially in regions subjected to pressure. If a metal splint or cast is used the points of pressure should be similarly watched and treated if irritation develops. If the cast is employed it may be necessary to cut a window in it, if the patient complains of persistent cutaneous pain in a given region.

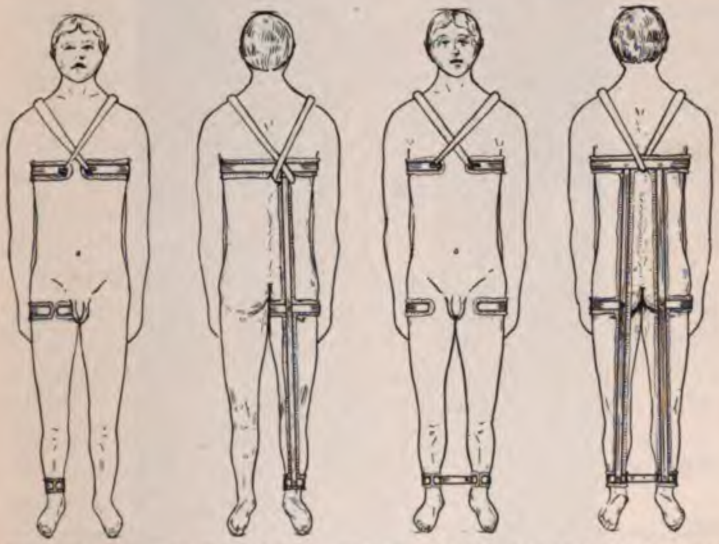

Fig. 620.—Diagrams illustrating the principles of the single and double Thomas hip splint.

The duration of the after-treatment depends on the progress of repair at the seat of fracture. It may be impossible to secure bony union in the aged and fixation may, in some cases, be prolonged indefinitely without result. In this type of case it is better to get the patient up and about after sufficient time has elapsed to give the fragments a fair chance to unite. Function will, of course, be imperfect but the patient will be better off than if a prolonged, futile immobilization is carried out. The older the patient the less the probability of bony union and the slower it will be in forming, if it does occur. In a middle aged person union should be well advanced at the end of eight or ten weeks but no weight should be borne on the injured member inside of three months. During the first eight weeks the hip should be immobilized, after this period gentle passive motion is advisable up to the third month, though all strain should be guarded against. Because of the varying rapidity in the process of repair seen at different ages and the different types of fracture encountered, no hard and fast rule can

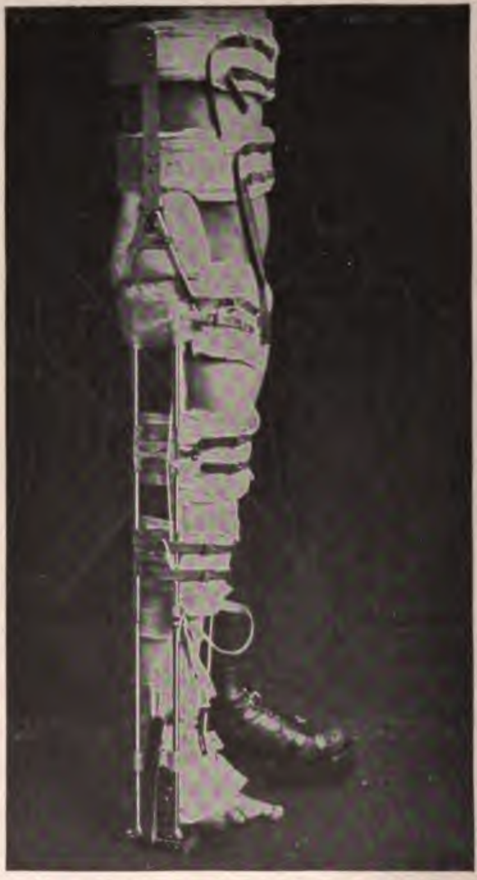

Fig. 621.—"The Ambulatory Pneumatic Splint" with hip attachment.

be laid down regarding the length of fixation. The most reliable information concerning the progress of union is to be obtained through the X-ray. Röntgenograms taken at the end of, say, eight, ten, and twelve weeks will show the condition of the fragments and the progress of repair, and will constitute the very best guide in the resumption of function. The patient's comfort during the after-treatment deserves much consideration, especially in elderly persons. The surroundings should be as bright and cheerful as possible. His friends should visit him frequently but should not be encouraged to stay long enough to weary him.

Prognosis.—Fracture of the neck of the femur is a serious injury even under the most favorable circumstances. In the aged it is particularly dangerous because of the low vitality of the patient. They not infrequently suffer greatly from shock and confinement and are subject to complications which, in their asthenic state, may produce death. Bony union has for years been considered as dependent on whether or not the fracture was within the joint cavity. The correct conditions, however, are probably whether or not the fractured surfaces are in firm apposition.

Under proper treatment union is to be expected in a healthy adult but in the aged it may or may not be obtained regardless of the treatment followed. Fibrous union means some impairment of function, yet a surprisingly useful hip may result even when there has been failure in bony union and some deformity exists.

The surgeon should never, even under seemingly favorable circumstances, promise bony union.

Injuries to the Femoral Neck in Children.—The epiphysis of the head joins the neck at about the eighteenth year, and the bony tissue of the neck is tougher and less brittle than in adult or advanced life. These anatomical variations account for the clinical picture accompanying injury of the femoral neck in childhood. A green-stick fracture of the neck of the femur or an epiphyseal separation of the head of the bone (incomplete as it usually is) is pathologically and mechanically quite different from fracture of the femoral neck as seen in the adult or the patient advanced in years. Accordingly the symptoms and course of the case are different. In an incomplete fracture of the femoral neck the head of the bone is depressed and the neck approaches more nearly a right angle. This change in the angle of the neck increases the strain on it and further bending of the neck follows unless all weight-bearing, jar and strain are removed. In "starting" of the epiphysis the pathology is somewhat different, though the result is practically the same. When the epiphysis is "started" it is displaced downward, and the fractured surface is only partially contacted with the end of the diaphysis. This downward displacement of the head is equivalent to a downward bending of the neck seen in green-stick fractures of the neck, and if the patient continues to use the member the result will be the same; namely coxa vara. Either of these injuries usually follows severe trauma and after being confined for a short time in bed the patient is up and about although limping. The limp is thought little of at first, but when this symptom increases instead of improving the surgeon's advice is sought. In some instances apparent immediate recovery takes place, and months or even years later coxa vara develops with progressive bending of the femoral neck and corresponding impairment of function. The immediate symptoms are slight, as a rule, and the condition may go unrecognized by the surgeon as well as the family. The apparent insignificance of the initial injury and the disastrous late consequences point out the necessity of the most careful examination following injuries of the hip in children. If the lower extremities are carefully measured it will usually be found that the injured member is from one half to one inch shorter than its fellow, and there may be slight eversion of the thigh. The X-ray should be employed when there is a history of injury to the hip, even if only for the purpose of exclusion.

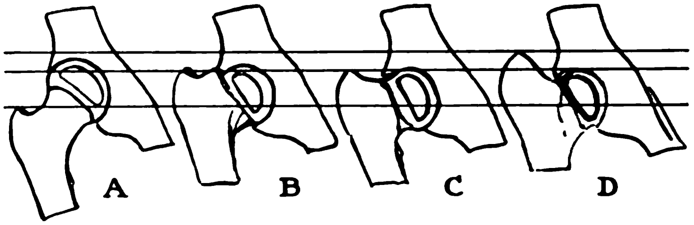

Fig. 622.—Diagrams to illustrate the development of coxa vara in a child following an injury to the hip in which the epiphysis is "started." *A.*, normal hip in child about four years old *B.*, same after injury which has started the epiphysis of the head and allows the trochanter to be displaced upward. *C.*, change in angle of neck resulting from the altered position of the head. *D.*, further change in the angle of the neck and raising of the trochanter, which result from the increased strain on the neck of the femur as it approaches the right angle. The elevation of the trochanter limits abduction by mechanical interference between the trochanter and the rim of the acetabulum. (After Whitman.)

If the case is seen soon after the initial injury it should be treated by rest in bed with Buck's extension applied and sand bags about the injured member, or the long side splint employed. If deformity exists after the acute traumatic stage has passed the plaster cast should be employed with the lower extremity in abduction according to the principles laid down by Whitman. (See Fig. 614.) At the end of a month this dressing may be replaced by an ambulatory hip splint with traction which is to be worn for a number of months, until union is solid and the danger of coxa vara passed. After this splint is removed the hip should be frequently examined by the X-ray to determine whether the strain incurred by use of the member is causing any change in the angle of the neck. If such is found to be the case the splint should be resumed with increased traction. If the case is seen only after the development of the secondary symptoms and coxa vara is present the traction ambulatory splint should be employed and worn for a number of months. If the deformity and disturbance in function are pronounced it is well to consider the advisability of an osteotomy to restore the angle of the neck.

CHAPTER XXXVIII.

FRACTURES OF THE FEMORAL SHAFT.

Surgical Anatomy.—The shaft of the femur consists of a tube of heavy compact tissue which is capable of withstanding greater strain than the shafts of other long bones. The diameter of the shaft grows larger and the compact tissue thinner as the extremities are approached. Ossification spreads from a single center which makes its appearance about the seventh week of fœtal life. The shaft is slightly curved with the concavity backward. The linea aspera serves to strengthen the concave posterior aspect and affords attachment to the adductor muscles. In the upper third of the shaft this line divides into three ridges, while in the lower third of the bone it bifurcates to form the supracondylar ridges. The femoral vessels cross the internal supracondylar ridge under a fibrous arch in the adductor magnus and become the popliteal vessels. From the point where the artery pierces the adductor magnus to the knee joint, it lies in close relation to the posterior surface of the bone, and in fractures of this region the vessel may be injured by a displaced fragment. The nerve and vein lie more superficially in the popliteal space and are less subject to injury from the bone, than is the artery. The greater part of the three surfaces of the femoral shaft are taken up by the attachments of the three vasti muscles which, together with the rectus, make up the quadriceps extensor. Fracture of the shaft of the femur is usually attended by great shortening, which results from the contraction of the powerful thigh muscles. The manner in which the fragments override will depend largely on the direction and nature of the break. In fractures of the upper third of the shaft, it is common to see the upper fragment displaced outward or outward and forward, while the lower fragment is drawn upward by the thigh muscles and displaced inward by the action of the adductor group. Outward rotation of the upper fragment not infrequently results from the pull of the ilio psoas. A transverse fracture with the serrated surfaces engaged will, of course, allow only of angular deformity as long as the fractured surfaces remain locked, but this condition is rare. Fractures in the lower third of the shaft are often accompanied by a backward displacement of the lower fragment as a result of the action of the gastrocnemius, the two heads of which are attached just above the condyles on the posterior

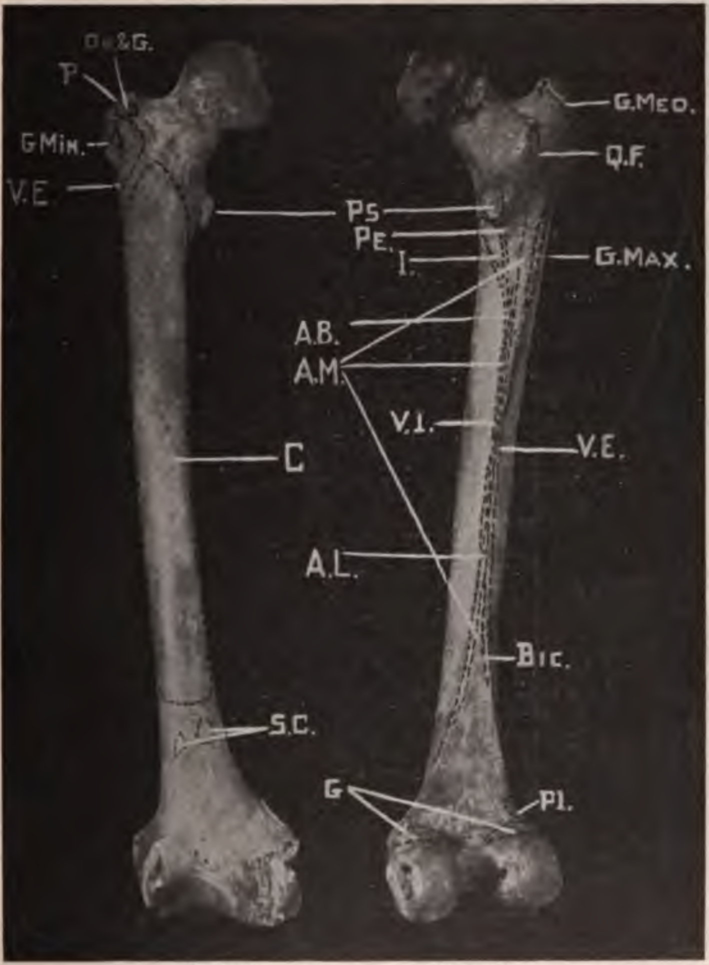

Fig. 623. Fig. 624.

Figs. 623 and 624.—Anterior and posterior surfaces of the right femur with attached muscles. *Ob. & G.*, Obturator internus and gemelli; *P.*, Pyriformis; *G.Min.*, Gluteus minimus; *V.E.*, Vastus externus; *G.Med.*, Gluteus medius; *Q.F.*, Quadratus femoris; *Ps.*, Psoas; *Pe.*, Pectineus; *I.*, Iliacus; *A.B.*, Adductor brevis; *A.M.*, Adductor magnus; *V.I.*, Vastus internus; *A.L.*, Adductor longus; *C.*, Crureus or Vastus intermedius; *Bic.*, Biceps; *S.C.*, Subcrureus; *G.*, Gastrocnemius; *Pl.*, Plantaris.

aspect of the bone. The powerful action of the thigh muscles usually results in pronounced deformity and their bulk renders palpation difficult.

Etiology.—Fractures of the femoral shaft constitute less than three percent of all fractures. Approximately one-fifth of the fractures of the femoral shaft occur in the upper third (not including the femoral neck), three-fifths occur in the middle third of the bone, while one-fifth is seen in the lower end. Fracture of the femoral shaft is the result of violence, direct and indirect and of muscular action, although the latter cause is probably never responsible for fracture in a healthy bone. Twisting strains frequently produce the spiral or oblique fracture so commonly seen in the upper and middle thirds of the shaft, while direct violence more often results in transverse fracture of the lower third. All

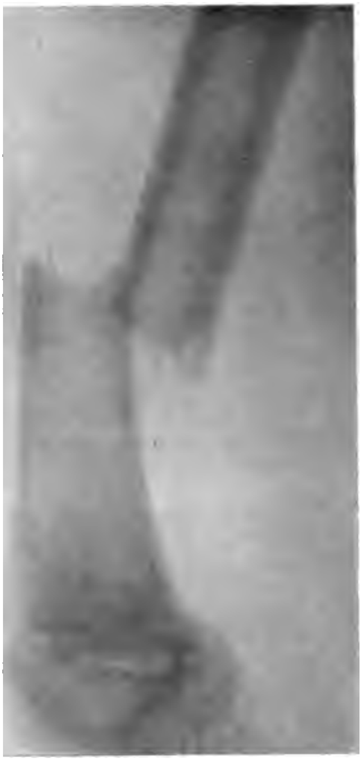

Fig. 625. Transverse fracture of the shaft of the femur with overriding and angular deformity.

types of fracture, however, may be seen in any portion of the shaft.

Symptoms.—Immediate and total loss of function is seen following the accident, except in the green-stick type occurring in children. Pain is usually pronounced and the deformity is characteristic. The limb below the break is rolled, either inward or outward (usually the latter), and the helplessness of the condition is typical. There is often considerable swelling at the site of fracture and in addition the thigh is actually thickened as a result of the overriding fragments and shortened muscles. The thigh is shortened according to the distance the fragments have overridden. The decrease in the length of the thigh can, as a rule, be recognized

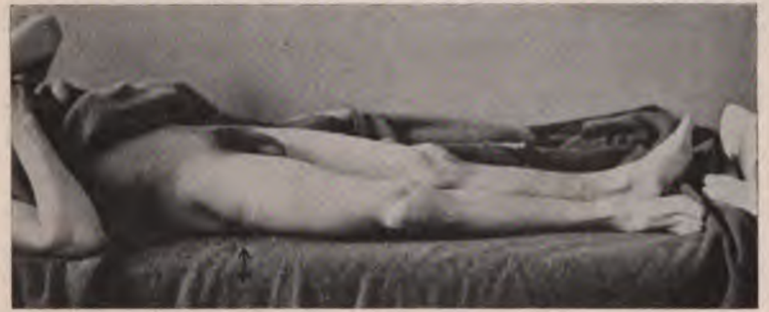

Fig. 626.—Fracture of right femur about twenty minutes after injury. Fracture caused by patient falling from first floor fire escape to the sidewalk. Violence transmitted through foot and leg. Note the shortening of the limb, the eversion of the foot and knee and the twisting of the muscles of the thigh.

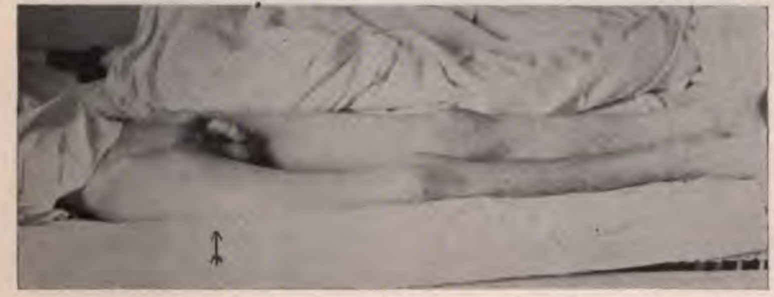

Fig. 627.—Case similar to the preceding about three and one-half months after injury. Fibrous union, deformity, loss of function. Fracture slightly oblique and about four inches below the great trochanter. Note the eversion, shortening, and wasting of the thigh muscles. Upper end of lower fragment is in contact with the lower surface of the femoral neck and united to it by fibrous tissue. Upper fragment abducted. Case operated. Incision on outer side of thigh, dense fibrous tissue broken up, ends of bone squared and wired together, most of the shortening and all of the eversion corrected. Function restored. Case first seen by author three and a half months after injury.

without the aid of the steel tape. Pain is greatly increased on manipulation. Abnormal mobility can usually be recognized as soon as the lower extremity is grasped and moved. Crepitus may be elicited if the fractured surfaces are in contact. The symptoms are, as a rule, pronounced and the shock considerable. Spasm of the thigh muscles is present and the resulting shortening usually increases during the first twenty-four or forty-eight hours, unless special preventive measures are employed in the treatment. Green-stick fracture sometimes occurs in children. In the presence of this condition the symptoms will be less pronounced, bowing of the femur will usually be apparent and lateral pressure on the thigh, in the direction of the bowing, will show an increased spring in the bone as compared with the uninjured femur.

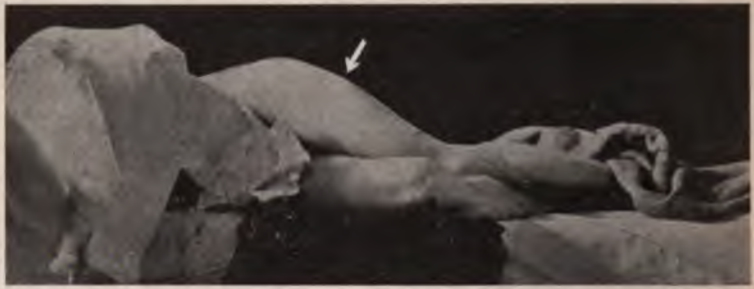

Fig. 628.—Fracture of left femur about one hour following injury. Lower end of upper fragment produces the prominence on the outer aspect of the thigh as indicated by the arrow. Patient assumes this position as a matter of choice. Leg much shortened though this is difficult to determine in the picture as the opposite thigh is flexed.

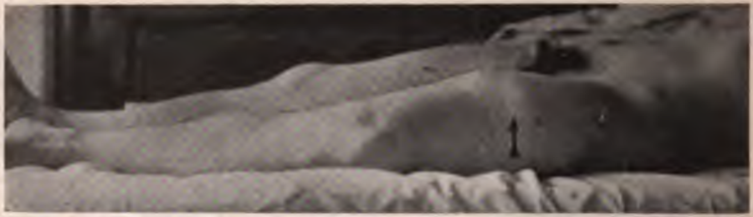

Fig. 629.—Fracture of the shaft of the femur at point indicated by arrow. Pronounced shortening with thickening of thigh at seat of fracture as a result of overriding of fragments. Complete eversion below break. Flail-like condition recognized when the limb is manipulated. Upper fragment displaced anteriorly. Photograph taken within twenty minutes of injury.

Diagnosis.—There is seldom any difficulty in recognizing fracture of the femoral shaft. The deformity, shortening, loss of function, abnormal mobility and crepitus render the diagnosis easy. The exact nature and position of the fracture, however, can only be learned by means of the X-ray or during operation when the fragments are exposed. Even under anesthesia, palpation and manipulation afford only an imperfect knowledge of the nature of the fracture. Fracture of the upper end of the femoral shaft might be confounded with fracture of the femoral neck, fracture of the rim of the acetabulum or fracture of the pelvis. The unaltered position of the great trochanter, its normal relation with Nélaton's line (see page 533) and the fact that it fails to rotate with the shaft, will serve to differentiate fracture of the femoral shaft from the conditions just enumerated. Fracture of the shaft of the femur in the new-born is devoid of subjective symptoms and must be recognized by the physical signs.

The less the thigh is manipulated the better: nearly all that can be learned by physical examination can be gathered by inspection alone, if the surgeon is observant. The deformity, helpless attitude of the limb, shortening, etc., and the history of the case should be sufficient evidence of the presence of fracture and its approximate location. Abnormal mobility and crepitus manifest themselves while the limb is being brought back into alignment incident to the application of Buck's extension and splints.

If doubt exists, careful measurements of the two lower extremities should be made and the same precautions are to be observed as already cited in fracture of the neck of the femur (page 539). The patient should lie straight in bed so that a line drawn through the two antero-superior iliac spines is at right angles to the median plane of the body and the lower extremities should be parallel. The usual deformity, however, with the lower extremity rolled outward, the thigh thickened and shortened and often angular displacement present, is, as a rule, too pronounced to require mensuration to establish a diagnosis. Moreover it will be most unwise to manipulate the thigh to bring it to a position which is parallel or symmetrical to its fellow, simply for the purpose of mensuration when the condition is already apparent through inspection alone.

Treatment.—The treatment of fracture of the femoral shaft varies with the age and condition of the patient and the nature and position of the fracture. The emergency treatment and the care of the case during the first week are practically the same in all instances and will be considered first.

The emergency treatment of these fractures is of importance in transporting the case from the scene of the accident to the hospital or home. Hospital facilities and surroundings are of the greatest advantage in the proper treatment of fractures of the thigh and the patient should be advised of this fact at the earliest possible moment. In transporting the patient the thigh and leg should be supported by some form of temporary splint to prevent further laceration of the soft tissues by the fragments. This may be accomplished by means of a bed slat or some other similar piece of wood which is bound or strapped to the lower extremity and trunk on the injured side. A blanket, sheet or towels may be used to secure the splint in position. A short splint on the inner side of the thigh will increase the security of the dressing. A satisfactory emergency

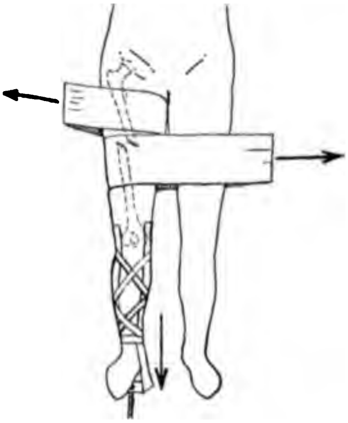

Fig. 630.—Diagram illustrating the manner in which lateral traction may be applied to bring the fragments into better position. The appliances used in the treatment of fractures of the femoral shaft are similar to those employed in the treatment of fractures of the upper end of this bone. (See Figs. 606 to 612.)

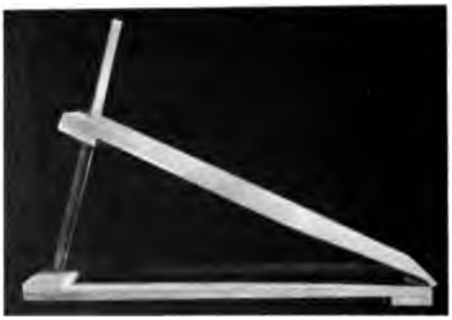

Fig. 631. Adjustable inclined plane used in the treatment of certain fractures of the femur. For other methods of fixing the thigh in various degrees of flexion see Figs. 615, 632, 633, 650, 651, 652, 653, 654 and 706.

splint may be made with broomsticks and a blanket. In moving the patient to or from the stretcher one person should confine his entire attention to the injured member to prevent motion between the fragments, while assistants raise and move him. As soon as

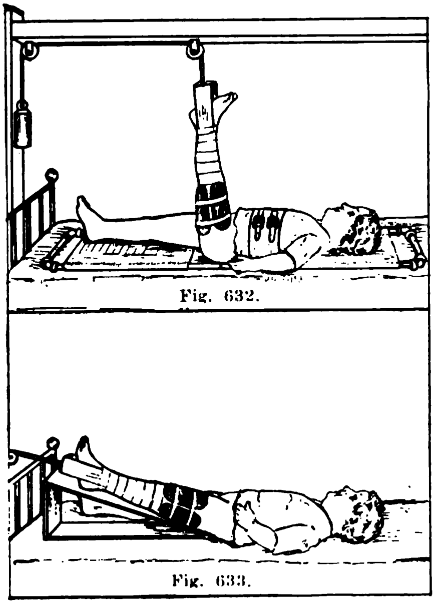

Fig. 632.

Fig. 633.

Figs. 632 and 633.—Showing the method of treating fracture of the shaft of the femur in children by vertical extension. At the end of two weeks the extremity is lowered to an inclined plane and treated in this position until union is complete. The patient is secured to a Bradford frame by means of a band about the body.

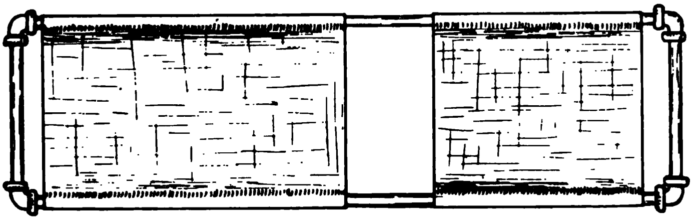

Fig. 634.—The Bradford frame. The frame is made of gas pipe and covered with canvas. It is usually necessary to employ some means of securing the patient (especially a child) to the frame. (See Fig. 632.)

the patient is placed in bed a Buck's extension apparatus should be applied to control the spasm in the thigh muscles. Coaptation splints and a long side or T-splint should be employed in preparation for the first week's treatment, during which time the traumatic reaction is to take place.

During the first week or ten days the usual case of simple fracture of the thigh is treated by means of Buck's extension, coaptation splints and the long side splint. Buck's extension and the long side or T-splint have already been described under the treatment of fractures of the femoral neck. Coaptation splints are short, light splints surrounding the thigh at the seat of fracture and are often misused with the idea of forcing the fragments together by means of lateral pressure. They serve a purpose in the treatment of these cases but their value has been greatly overestimated. They are fairly efficient in maintaining reduction after it has been accomplished but have little or no effect in forcing displaced fragments back into position. If applied too tightly they are capable of doing considerable harm by interfering with the circulation or by forcing the muscles against sharp fragments. The coaptation splints should be well padded and are best held in position by means of circular strips of adhesive plaster.

All the materials for the application of Buck's extension, together with the side splint and coaptation splints should be at hand and ready for use before the parts are disturbed. It will usually be best to have the patient anesthetized to relax the muscles. The thigh should be brought back into alignment with as little manipulation as possible. An attempt at accurate apposition of the fractured surfaces should be made at this time, yet reduction immediately following the accident is usually only partially successful. This is because most fractures of the shaft are oblique or spiral, and although anesthesia relaxes the muscles, yet when the patient regains consciousness the spasm is almost sure to again displace the fragments, even though heavy extension is employed. As a rule the best that can be expected at this time will be an approximate reposition. Proper reduction can best be accomplished at the end of four or five days, or a week, when the extension apparatus has so exhausted the muscles that the displacing strain, resulting from local spasm, is practically negligible, when guarded by a heavy weight at the end of the extension cord. An accurate knowledge of the nature and position of the fracture is most valuable in attempting a permanent reduction, and for this reason an X-ray plate should be taken soon after the accident. By a study of the Röntgenogram and the symptoms of the case we are able to determine whether ordinary treatment will give good results or whether operative intervention will be necessary to accomplish and maintain good reduction. In a simple transverse fracture it will often be possible to secure a satisfactory engagement without operation, but when the fracture is spiral or oblique, as is so frequently the case, it will usually be necessary to resort to the open method to obtain the best results. Non-operative treatment is reserved for those rare cases in which good reduction can be accomplished and maintained by manipulation and traction and immobilization, and in cases in which operation is contraindicated on constitutional grounds. If good reduction is possible without operation the case may be treated, until union takes place, with the apparatus just described: namely Buck's extension, coaptation splints and the long side splint or the T-splint. After the traumatic reaction has subsided the cast may be employed instead of the above apparatus. The cast is usually applied with the lower extremity in the straight, extended position, but if the surgeon finds that some other position is more favorable to the retention of the fragments, he should employ whatever attitude is thus shown to be best adapted to the needs of the case. In any event the cast should extend from the waist to the foot and should be lined with sheet cotton to prevent irritation. The upper portion of the cast secures a firm hold on the pelvis while the lower portion immobilizes the thigh and leg.

In fractures of the upper third of the shaft the upper fragment frequently shows a tendency to outward, or outward and forward, displacement and accordingly moderate flexion, or flexion with abduction, is often found to be the position favoring retention. This may be obtained by means of the double inclined plane, with extension from the knee in the line of the axis of the femoral shaft, or a cast may be applied with the hip slightly flexed, or flexed and abducted, with a corresponding position of flexion at the knee.

In fractures in the lower third of the bone the lower fragment is often displaced backward by the action of the gastrocnemius, and when this occurs, flexion at the knee is the position in which the condition should be treated and the double inclined plane, or cast in flexion, are the appliances used. (See Chapter XXXIX, "Fractures of the Lower End of the Femur.")

These attitudes of fixation may favor the retention of fragments but are seldom really efficient in accomplishing good results. The fact that these positions are needed to favor reduction and retention usually means that the case should be subjected to operation to accomplish really good apposition.

In children under ten years of age, fractures of the femoral shaft are best treated by vertical suspension of the lower extremity, while the child rests on a Bradford frame in the recumbent position. A Buck's extension apparatus is applied as already described in the treatment of fractures of the hip, with this exception, the line of extension is vertical instead of horizontal. The cord passes through a pulley directly over the middle of the bed and on a vertical line with the hip. The lower extremity is thus maintained in a position perpendicular to the trunk. It is best to have the child secured to a Bradford frame, which greatly facilitates the after-care of the case and prevents the patient from moving about to the extent of disturbing the fixation. This position of vertical extension is maintained for about two weeks, after which the lower extremity is lowered to an inclined plane (about 40 degrees), and extension kept up in this position for another week. A plaster spica of the pelvis and lower extremity, or a hip brace, may then be applied and the patient allowed up and about with the aid of crutches and a high sole on the shoe of the opposite foot. The thigh should not be subjected to strain until the surgeon is sure of solid union, otherwise a bowing deformity may result. (See Fig. 632.)

Fractures of the thigh in patients advanced in years present some of the same problems already described under the treatment of fractures of the hip in the aged (see page 547). Hypostatic pneumonia or bedsores and other complications may develop if the patient is long confined to bed. Accordingly some form of ambulatory treatment should be adopted as soon as the shock and traumatic reaction have subsided. The Thomas hip splint, plaster cast, or "ambulatory pneumatic splint" with hip attachment may be used in getting the patient on his feet. In very old and feeble persons it is often best to employ the cast (see page 548) with the thigh and knee flexed so that they may sit in a chair during the day and rest in bed at night.

In fractures of the femoral shaft in the new-born the thigh is best treated in complete flexion, being bound to the trunk in this position. The fœtal attitude is thus taken advantage of to secure immobilization. The thigh and abdomen are previously dried and powdered and a few layers of soft linen placed between them, before the thigh is fixed.

In fractures of the lower third with backward displacement of the lower fragment the double incline plane may be used instead of the plaster cast and is much more appropriate in the early part of the after-treatment, during the time the acute traumatic inflammation is at its height.

Operative Treatment.—A large proportion of fractures of the femoral shaft demand operative intervention if the best possible results are to be obtained. Fractures of the upper and middle thirds are usually of the spiral or oblique type and nothing, as a rule, will secure the fragments in accurate apposition except direct fixation following open reduction. In the lower third of the shaft it is more often possible to secure good reduction by non-operative treatment, yet fracture in this region often demands the open method. The shaft of the bone is usually best exposed through a longitudinal incision on the outer aspect of the thigh in the region of the fracture. With the fragments exposed, strong traction is made on the lower extremity and the serrated surfaces fitted together. They are then secured by means of wire or a heavy Lane plate. The Nichols extension frame is one of a number of appliances which are of value in exerting traction and countertraction during operation (see Fig. 635). Nowhere in the body is internal fixation subjected to greater stress than here in the shaft of the femur, and the material used should be strong enough to serve the purpose, pending the formation of bony callus. A good example of the fixation of a double spiral fracture of the middle of the femoral shaft with wire is shown in Figs. 636 and 637. When wire is employed two points of fixation should be had to secure the proper leverage and to prevent angular deformity. If the wire is passed circularly about the shaft it will often accomplish as much as if it were passed through drill holes in the bone. In encircling the shaft

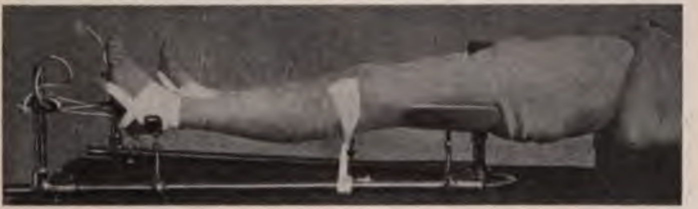

Fig. 635.—The Nichols frame. An appliance of great advantage in operating on fractures of the femoral shaft. A steady and powerful traction is maintained on the limb during the operation.

the instrument carrying the wire should hug the bone closely to avoid injuring the femoral artery or one of its perforating branches which, in the middle third of the shaft, lie in close relation with the internal border of the bone. If a Lane plate is used it should be heavy and long, preferably of the Sherman-Pierce type, and should be provided with six screw holes. When the fixation is completed

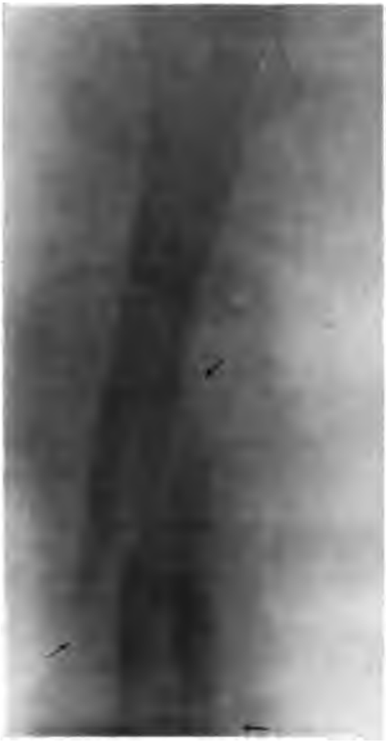

Fig. 636.

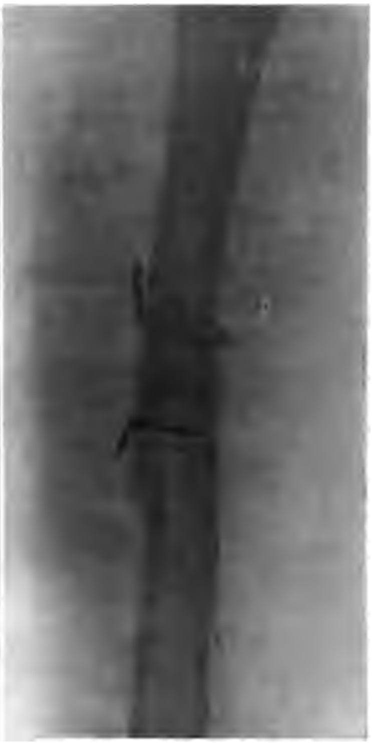

Fig. 637.

Fig. 636. -Double spiral fracture of femur with unattached fragment. X-ray plate taken after everything in a non-operative way had been done to accomplish reduction.

Fig. 637. --Same case after operation. Fragments in accurate apposition with the result that the lower extremity shows no shortening.

the thigh should be raised from the table and in this position it should be capable of sustaining the weight of the leg without giving. The muscles should be brought together with a running suture of catgut and the skin closed with silk-worm gut or horse hair. A plaster cast should then be applied, after proper dressings have been placed on the wound and the lower extremity covered with sheet cotton. The cast should extend from the waist to the foot, leaving the toes exposed, so that the condition of the circulation in the extremity may be watched during the after-treatment. Twenty-four to forty-eight hours following the operation a window should be cut in the cast, the wound inspected and gentle pressure made to express any dead blood which may have collected in the wound.

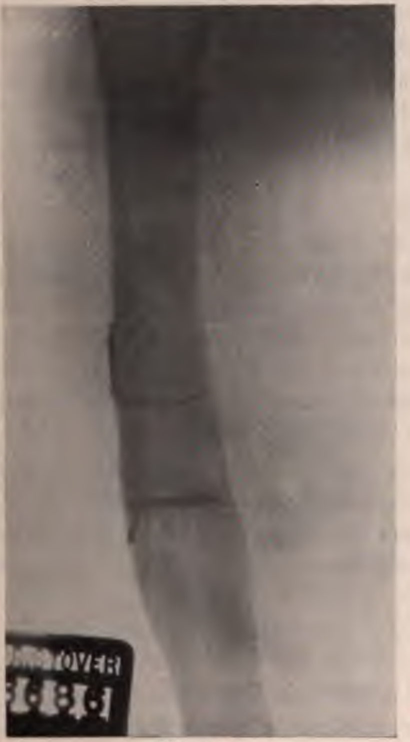

Fig. 638.

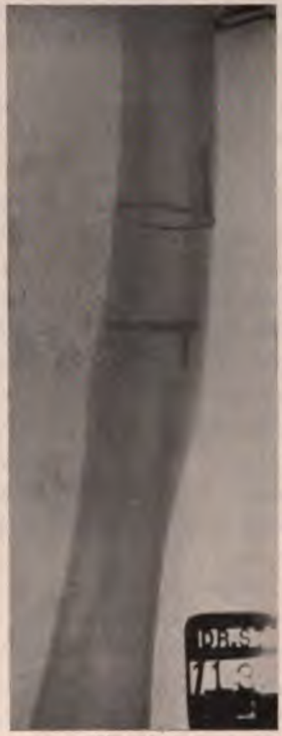

Fig. 639.

Fig. 638.—Same case two years following operation. Perfect restoration of function.

Fig. 639.—Same case six years after operation. Note the condition of the callus and wires, also the reopening of the medullary canal.

In compound fractures of the thigh operative intervention is practically always indicated. The wound should be enlarged if necessary and all devitalized tissue trimmed away. When this has been done the wound should be washed with a few gallons of sterile salt solution and the muscles and skin accurately approximated (see "Treatment of Compound Fractures," page 789).

After-Treatment.—The duration of the after-treatment varies considerably with the accuracy of apposition and the age of the patient. Union will therefore take longer in non-operated cases than in cases which have been subjected to the open method (see "Operative Treatment of Fractures," page 754). In a healthy adult, union will usually have taken place in from six weeks to two months, although refracture may easily occur at this time if the limb is subjected to any considerable strain. In children union can usually be expected in from four to six weeks. In the aged union may be very much delayed and in some cases it may be impossible to obtain bony union at all. No matter what line of treatment is followed the case should receive the most careful attention during the after-treatment. The patient should be seen daily for the first few weeks. If the fracture is treated by extension and splints, frequent adjustments will be necessary to keep the patient comfortable and to maintain the fragments in proper position. During the first few days the weight should be heavy (usually about twenty-five pounds in the adult) to control the spasm in the thigh muscles which, at this time, is at its height. The weight should be gradually diminished as the muscles become exhausted and the spasm less active. Frequent measurements of the lower extremity should be made to determine the extent of the shortening and the influence of the extension apparatus in overcoming it. If the cast or ambulatory splint is used it will require adjustment from time to time and the parts with which it comes in contact should be carefully watched for evidences of irritation. If, during the time the cast is being worn, the patient complains of persistent irritation in a given place, a window should be made to determine the condition of the skin or to treat a sore if one has developed. Following operative intervention the temperature chart should be watched for evidences of infection and the wound should be inspected within the first few days. Infection need not be expected, however, if the proper surgical technique has been followed out.

If ambulatory treatment is not employed it is usually best to keep the patient in bed for a week or so following the removal of the splints. During this time massage and passive motion should be instituted. When the patient is first allowed up no weight should be borne on the injured member until he is thoroughly adept with the crutches. The thigh should be inspected daily during the time he is beginning to bear weight on it and if the slightest evidences of bowing develop he should be again placed in bed and extension apparatus applied. It is advisable at this time to have an X-ray plate made to determine the condition of the callus.

Prognosis.—Fracture of the femoral shaft is always a serious accident and the prognosis should be guarded. In unoperated cases shortening is the rule and angular or rotary deformity is not uncommon. If the shortening is less than an inch or an inch and a half, and the general alignment of the shaft is not changed, the result is said to be good. If the shortening is not greater than an inch and a half the tipping of the pelvis will compensate for the deficiency in the length of the lower extremity so that walking will be practically normal. Pain and weakness in the injured thigh are common following fracture of the femoral shaft and often persist for years. Little can be done to alleviate them. The more perfect the reduction the more complete and prompt will be the restoration of function. The results following the open treatment with internal fixation of the fragments are decidedly better than those following the non-operative method. It is often possible to secure union without shortening, even in spiral fractures, if recourse is had to operative intervention.

If infection follows a compound fracture the outlook is often serious. With free drainage of the parts the danger is greatly reduced and bony union may follow.

CHAPTER XXXIX.

FRACTURES OF THE LOWER END OF THE FEMUR.

Under this heading are included the various fractures occurring in the lower end of the bone, some of which enter the joint cavity of the knee. Separation of the lower femoral epiphysis is also considered under this heading instead of being taken up separately as is customary.

Surgical Anatomy.—The lateral surfaces of the large expanded lower extremity of the femur are subcutaneous and can be palpated without difficulty. With the knee flexed the upper margin of the trochlear surface may be felt anteriorly. The two heads of the gastrocnemius are attached posteriorly just above the condyles. To the external surface of the outer condyle (outer tuberosity) is attached the tendon of the popliteus, and at the lower end of the external supracondylar ridge is the origin of the plantaris. In the notch between the condyles are attached the upper ends of the crucial ligaments. The popliteal artery lies in close relation with the posterior surface of the bone, from the point where it crosses the internal supracondylar ridge to the bottom of the intercondyloid notch. It may be injured in this position when fracture of the lower end of the bone occurs. The vessel is more often temporarily compressed than permanently injured, which fact accentuates the importance of early reduction. The popliteal nerve and vein lie more superficially than the artery, and accordingly are much less frequently injured by displaced fragments.

The most common fracture of the lower end of the femur is transverse and a short distance above the condyles. Occasionally the lower fragment is split vertically, thus producing the typical T- or Y-fracture which enters the joint cavity. A more severe type of T-fracture is one in which the lower end of the shaft is driven into the lower fragment with considerable comminution and a vertical splitting into the intercondyloid notch. If it were not for the intercondyloid notch the T-fracture would probably not occur.

Either condyle may be broken off from the remainder of the bone.

When force is applied to the knee in a lateral direction or when violence is transmitted longitudinally through the leg, the tuberosities of the tibia play an important part in the pressure they may exert against the condyles of the femur. In like manner the pull of the lateral ligaments may result in fracture of a condyle when the knee is subjected to lateral angular displacement. It is more common for the lateral ligaments to tear away only their bony attachments on the femoral tuberosities. This condition is usually represented by a portion of the surface compact tissue, together with some of the underlying cancellous bone, remaining attached to

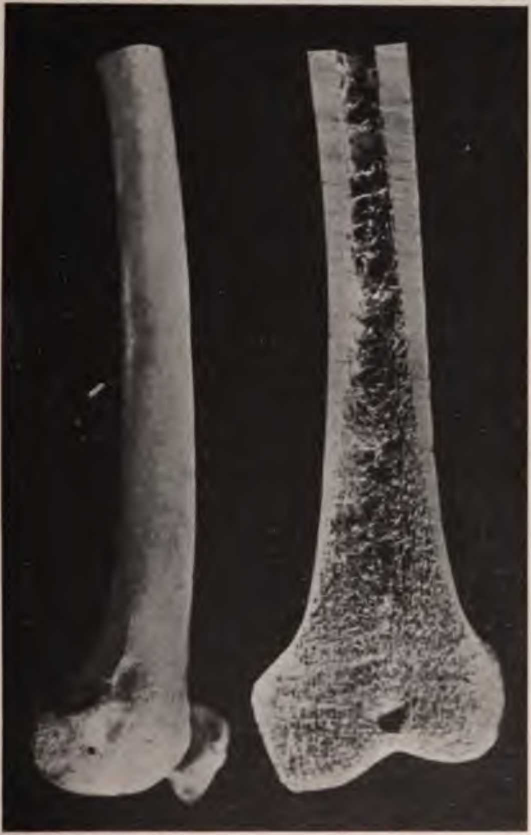

Fig. 640. Fig. 641.

Fig. 640.—Lateral view of the lower end of the femur.
Fig. 641.—Coronal section of the lower end of the femur.

the ligament which is torn away and displaced from the tuberosity. This type of fracture is more properly a complication of subluxations or "sprains" of the knee, and will be considered under "Dislocations of the Knee," page 613.

The epiphyseal cartilage corresponds roughly to a horizontal plane passing just above the condyles and through the adductor tubercle. The top of the trochlear surface just touches this plane. The lower femoral epiphysis is ossified from a center which makes its appearance shortly after birth. Epiphyseal separations cannot occur after the twentieth year since the epiphysis joins the shaft at this time. In fact they are rare after the sixteenth year.

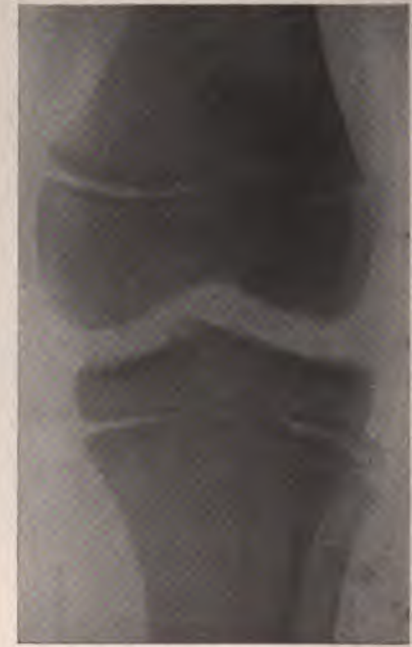

Fig. 642.—Röntgenogram of the knee showing the locations of the epiphyseal cartilages.

The injuries, then, to which the lower end of the femur is subject are: supracondylar fracture, T-fracture, fracture of either condyle separating it from the remainder of the bone, epiphyseal separation and avulsion of a portion of the surface of a tuberosity by the pull of the ligaments. In rare instances we may see a longitudinal splitting of the lower end of the shaft which extends through the

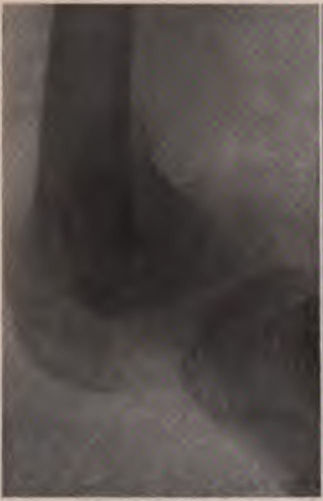

Fig. 643.

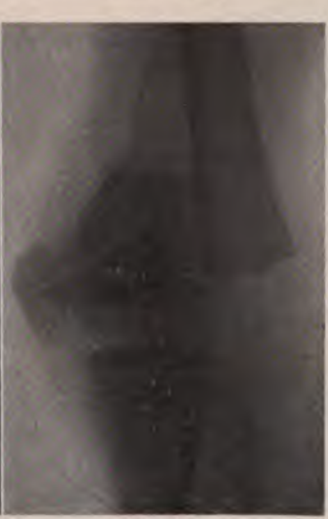

Fig. 644.

Fig. 643.—Fracture of the lower end of femur with angular deformity and crushing of cancellous tissue in the lower fragment.

Fig. 644.—Supracondylar fracture with pronounced overriding deformity.

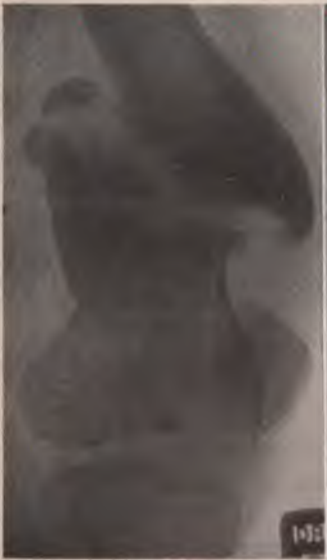

Fig. 645.

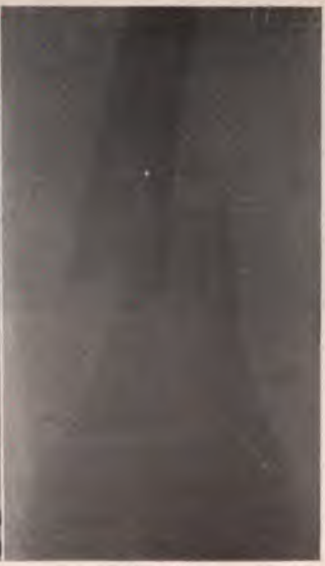

Fig. 646.

Fig. 645.—Old displaced fracture with refracture through callus.

Fig. 646.—Fracture of femur with lateral overriding deformity.

lower end of the bone into the joint cavity. In some cases we may see a portion of the surface of the tuberosity driven inward by severe violence confined to a small area.

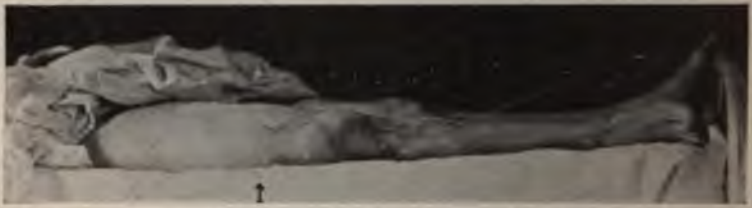

Fig. 647.—Fracture of the lower third of the femoral shaft. Note the shortening, external rotation and thickening of the thigh. Lower fragment displaced posteriorly. Case first seen twenty-four hours after injury at which time this photograph was taken.

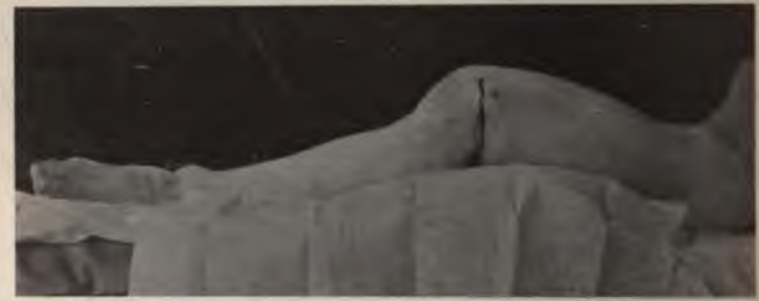

Fig. 648.—Compound comminuted fracture of the lower end of the femur. The lower end of the upper fragment is displaced anteriorly and has penetrated the skin. The resulting wound shows black in the photograph and blood is seen trickling down the side of the knee.

Symptoms.—The symptoms vary with the age of the patient and the severity and nature of the injury. In supracondylar fracture, fracture of one of the condyles or epiphyseal separation, the loss of function is complete. The patient is unable to stand on the injured member or to raise the foot from the bed. Deformity is usually present and varies with the position of the fracture. In the simple supracondylar type the lower fragment may be displaced in any direction. If it is free to move (if not obstructed by the lower end of the upper fragment) the action of the gastrocnemius will tend to displace it backward. In any type of fracture of the lower end of the femur it is more common to see the lower end of the upper fragment displaced forward and downward while the lower fragment is displaced backward. In epiphyseal separations the reverse is usually true, the epiphysis is displaced forward and upward, in front of the lower end of the diaphysis. In T-fracture or fracture of one of the condyles the transverse diameter of the lower end of the femur is usually increased. Injury to the popliteal artery may occur in any of these fractures of the lower end of the femur, especially in epiphyseal separations, and the resulting symptoms of disturbed or destroyed circulation will depend on whether or not the artery has been compressed or lacerated. In fractures of the lower end of the femur it is not uncommon to see the lower end of the upper fragment projecting through the skin above the patella. In epiphyseal separations the condition is often rendered compound by the lower end of the diaphysis projecting through the skin covering the popliteal space.

Abnormal mobility is regularly present but the proximity of the knee joint renders this symptom at times difficult to recognize. In fracture of one of the condyles or in T-fracture the loss of lateral stability in the knee is usually pronounced. Crepitus may be elicited unless the fragments have overridden so that their serrated surfaces are no longer in contact. In epiphyseal separations the epiphysis is, as a rule, displaced anteriorly and upward and crepitus cannot be elicited until the fractured surfaces are brought back into contact and even then it is soft and cartilaginous rather than bony.

Diagnosis.—If the case is seen early before the onset of swelling, it will usually not be difficult to recognize the nature of the injury. There is, as a rule, disturbance in the alignment of the bones of the thigh and leg which can be determined by inspection. Shortening of the thigh is the rule since the fragments so frequently override. Fracture in this region without deformity is the exception. Abnormal mobility is usually characteristic. The lateral stability of the knee is impaired, especially when the lower fragment is divided into two or more pieces. Where the swelling is great it may be difficult to determine whether the fracture is in the lower end of the femur or the upper end of the tibia.

The deformity in these fractures is variable, though the most common displacement is backward in the lower fragment. In epiphyseal separations the deformity is more uniform with the epiphysis displaced upward and forward. This condition is most commonly seen about the tenth or twelfth year and the crepitus elicited is soft and cartilaginous rather than bony.

All unnecessary manipulation for diagnostic purposes should be avoided because of the liability of injury to vessels and nerves.

The manipulations incident to reduction will afford as much information to the surgeon as those conducted simply to establish a diagnosis. When the X-ray is available the most complete information concerning the fracture may be gained without disturbing the parts.

Treatment.—Anesthesia is essential in reducing fractures of the lower end of the femur. With a simple supracondylar fracture reduction should be accomplished as soon as possible and the fragments immobilized in splints. Difficulty is sometimes experienced in bringing the fractured surfaces back into apposition and when such is the case we should resort to operative intervention. The fact that the popliteal artery may be injured during reduction should never be lost sight of and accordingly manipulations should be most guarded. If reduction cannot be accomplished by traction and manipulation, the open method should be instituted at once, especially if there is the slightest indication that the popliteal artery is being compressed. In manipulating the fragments pressure should never be made in the popliteal space lest the artery be driven

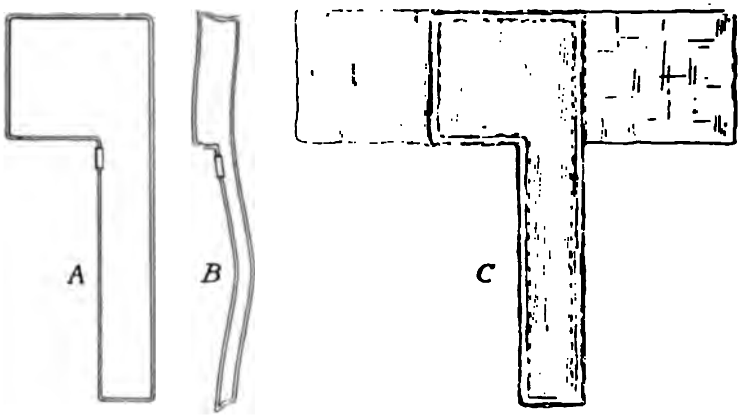

Fig. 649. Cabot posterior wire, hip splint. *A.*, Wire bent to make splint. ***B.***, Side view showing bends to conform to the posterior surface of the lower extremity and hips, with knee in a position of slight flexion. *C.*, Splint covered and lateral flaps attached to encircle the trunk

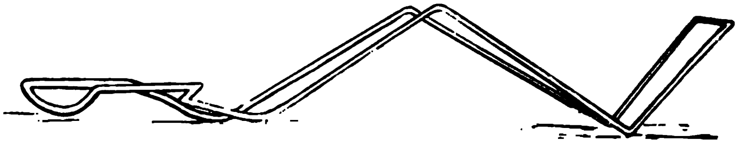

Fig. 650 Cabot posterior wire splint bent to be used as double inclined plane.

against the end of one of the fragments. Pressure to force the lower end of the upper fragment forward should be made in the middle of the thigh posteriorly, where there will be no danger of injury to important soft tissues. In the presence of a T-fracture or a fracture of one of the condyles, an attempt should be made to force the condyles together as reduction is being accomplished. This is an important matter since separation of the femoral condyles means loss of proper alignment between the femoral and tibial articular surfaces with subsequent disturbance in the function of the knee joint. If the fracture is near the knee and the lower end of the upper fragment is displaced forward the prominence thus produced

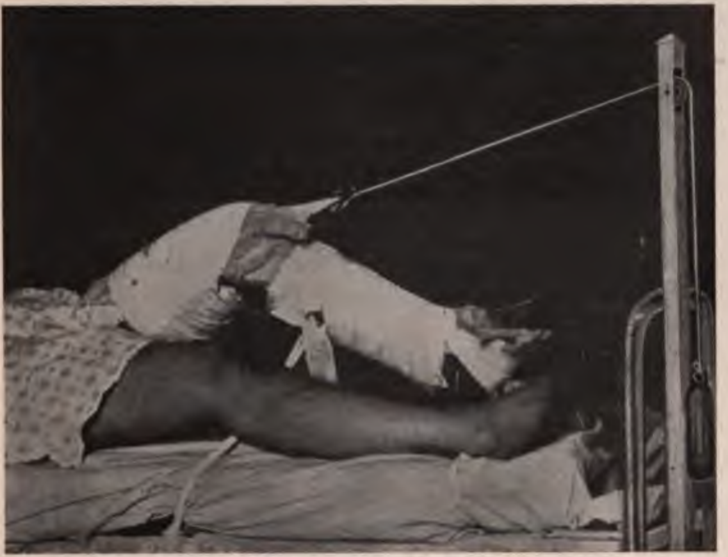

Fig. 651.—Dupuy's adjustable splint used as a double inclined plane in a case of fracture of the femur. Extension in the long axis of the femur is employed to maintain reduction.

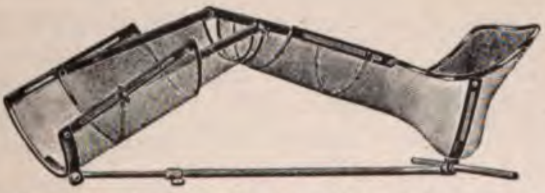

Fig. 652.—Dupuy's adjustable metal splint for the treatment of fractures of the lower extremity.

may interfere with the action of the patella and quadriceps after union has taken place.

In separation of the epiphysis reduction should be accomplished at once and with the least possible manipulation. Gradual flexion of the knee while pressure is being exerted on the epiphysis will aid materially in effecting reduction. If reduction cannot be effected by traction, counter-traction, flexion and direct pressure on the epiphysis, it should be accomplished by operative intervention.

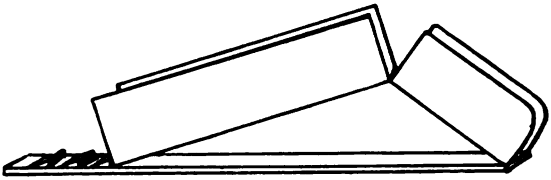

Fig. 653.—Adjustable double inclined plane, fracture box.

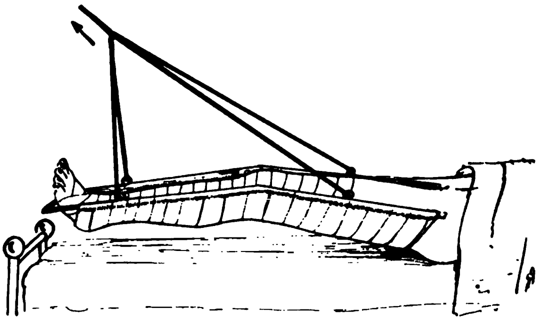

Fig. 654.—Hogden's splint. This splint may be used as a double inclined plane. The manner in which the ropes are arranged affords traction as well as suspension.

Repeated attempts at reduction of an epiphysis, with intervals of delay, are absolutely to be condemned. The sequel of such surgery is amputation. If the first attempt is unsuccessful, operation should be performed *at once*.

Operative Treatment.—Operation is indicated when good reduction cannot otherwise be accomplished. An incision along the inner border of the quadriceps extensor will expose the fragments, and manipulation of the lower extremity may be aided by direct traction on the displaced fragments, by means of bone hooks or forceps. Increasing the angular deformity may render reduction easy which would otherwise have been difficult. After the serrated surfaces have been engaged the angular deformity is corrected and the fragments brought back into good alignment. If the fracture is of the T-type it is often advisable to make two longitudinal incisions, one on the inner and the other on the outer aspect of the thigh opposite the lower end of the bone. With the parts thus exposed the condyles are forced together and back into position so that they properly fit the articular surfaces of the tibia. If a tendency toward recurrence of deformity is noted they should be secured in proper relation with each other by some means of internal fixation. If two holes are drilled transversely through the lower end of the bone above the condyles, a wire may be passed through the bone from one side to the other and back again, thus holding the fragments together. A Lane plate may be used on the anterior surface of the bone if the displacing strain is not too great. It should be remembered that the lower end of the femur is covered by a very thin layer of compact tissue while the interior of the bone is composed of a cancellous structure which offers an exceedingly poor foothold for screws, nails or pegs. The most secure fixation, therefore, is the transverse wiring just described. If transverse wiring is employed below the upper border of the trochlea care should be exercised to avoid drilling into the supracondyloid notch. The drill holes should, therefore, be placed well forward. (See "Anatomy of Lower End of Femur," page 574.

The knee-joint should not be opened unless it is found that proper fixation cannot otherwise be obtained. With reduction and fixation of the fragments accomplished the wound or wounds are closed and the lower extremity immobilized in whatever position shows the least tendency toward recurrence of deformity, as demonstrated during operation. Extension, semiflexion or flexion may be employed. As a rule, however, it will be found practicable to immobilize the lower extremity on a ham splint in a position just short of complete extension. When the fracture is treated in this position a Buck's extension following operation is usually indicated to relieve the muscular spasm, steady the member and relieve the pressure between the articular surfaces of the tibia and femur. Padding of the splint for the purpose of exerting pressure in the popliteal space to effect or maintain reduction is not permissible. Tenotomy of the tendo Achillis to overcome backward displacement of the lower fragment has been advised and practised but is probably an unwise measure. It is often unsuccessful and by no means as satisfactory as open treatment with direct fixation of the fragments.

There is usually little tendency toward recurrence of deformity following reduction of an epiphyseal separation, if the lower extremity is treated in the semiflexed position. Should the exception, however, be encountered and internal fixation prove necessary, absorbable suture material is the only material which should be used in holding the epiphysis in place. Loops of wire or a Lane plate should not be used across an epiphyseal cartilage. A light plaster cast extending from the groin to the ankle with the knee in semi-flexion will usually be found quite satisfactory in immobilizing the parts. It should not, however, be employed until after the traumatic reaction has subsided. If the cast is cut open before the plaster has dried it may be applied immediately following the operation.

After-Treatment.—Considerable traumatic reaction usually follows the accident, and during the first week repeated adjustments will be necessary in making allowances for the onset and subsidence of swelling. Traumatic arthritis of the knee is the rule, especially in epiphyseal separations and fractures entering the joint cavity. The knee should be snugly bandaged and an ice cap should be kept in position most of the time during the first week. A long side splint such as used in fractures of the shaft of the bone, adds greatly to the security of immobilization when the fracture is treated in the extended position. If the lower fragment shows a tendency to posterior displacement not controlled by straight Buck's extension, a double incline plane should be employed or the lower extremity put up in a cast in a flexed or semi-flexed position. At the end of six or eight weeks the dressings should be removed and passive motion begun. In another week or ten days the patient may be allowed out of bed and may begin the use of the member cautiously. He may bear a little weight on it while getting about with the aid of crutches and a moderately high sole on the opposite foot.

In children union is much more rapid while in the aged it may be very much delayed.

The usual treatment of epiphyseal separations is with the knee in a position of semiflexion. At the end of three or four weeks the knee may be carefully brought to the ex [illegible] sition and massage begun. Guarded passive motion should be instituted within the next few days. At the end of six weeks all dressings should be removed and the child allowed to lie unrestrained in bed for another two weeks. If the ambulatory pneumatic splint is used, or some other equally efficient appliance, the child may be up and about during this time. Function may be resumed gradually during the eighth and ninth weeks. At the end of two and

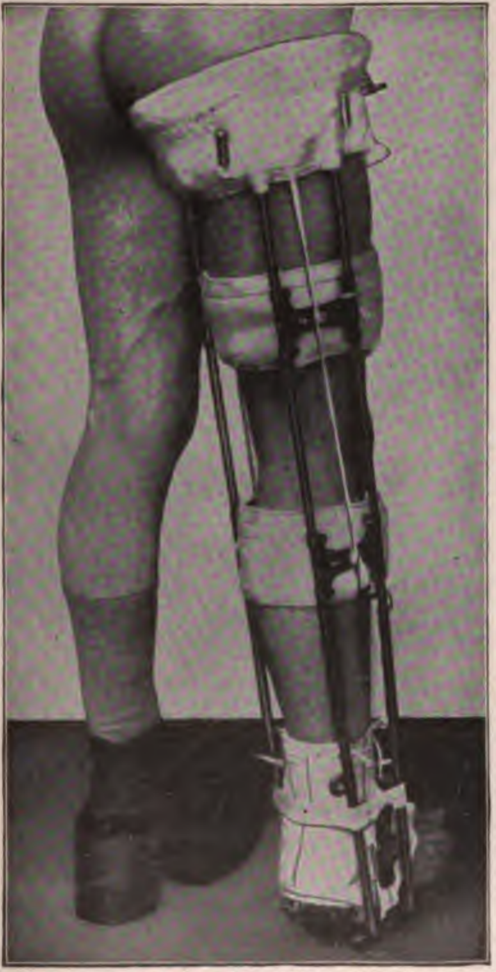

Fig. 655.—Ambulatory pneumatic splint (adjustable), showing application for all fractures but the hip, without any additional supports to the limb or hip-joint immobilizing attachment.

a half months the patient should be bearing his full weight on the leg.

If at any time during the after-treatment gangrene or septicemia should develop as a result of destroyed circulation or infection, prompt amputation will usually be necessary to save the patient's life.

Prognosis.—Fracture of the lower end of the femur is at best a serious condition. Infection of the knee-joint or laceration of the popliteal artery are conditions which render the fracture itself only of secondary importance. Epiphyseal separation has a particularly bad prognosis, especially when compound. Gangrene of the leg is not an uncommon sequel when the popliteal artery is injured and death has resulted in many instances from gangrene, infection, embolism, etc. Disturbances in the subsequent growth of the bone following epiphyseal separations are not common if recovery has taken place with the fragments in good reduction. The surgeon, however, should warn the parents of the untoward possibility so that he may not be unjustly blamed later on.

Simple fracture of the lower end of the femur without arterial damage is usually followed by good function if the condyles do not unite in deformity. Joint adhesions may occur in the knee. Their severity is lessened by the proper use of Buck's extension during the height of the traumatic arthritis. A chronic villous arthritis is not uncommonly seen following fractures in this region.

CHAPTER XL.

FRACTURES AND LUXATIONS OF THE SEMILUNAR CARTILAGES.

Surgical Anatomy.—The semilunar cartilages are two crescentic masses interposed between the articular surfaces of the tibia and femur and serve to deepen the articular surfaces on the head of the tibia. The superficial margins are thick, correspond roughly with the outline of the upper end of the tibia and are attached to the deep surface of the capsule of the knee-joint. The central margins of these cartilages are thin and lie free in the joint. Between the articular surfaces of the tibia we have attached from before backward: the anterior end of the internal semilunar cartilage, the anterior crucial ligament, the anterior end of the external cartilage, the posterior end of the same cartilage and, lastly, the posterior crucial ligament. It will be seen from this, that the two extremities of the external cartilage practically meet at the spine of the tibia while the extremities of the internal cartilage are separated by a considerable distance. The deep structure of these cartilages is fibrous while the surface is composed of hyaline cartilage. They are triangular on cross-section. The circumference of each cartilage is bound to the borders of the tuberosities of the tibia by the capsule of the joint, which is continuous on the outer and inner aspects of the articulation with the lateral ligaments. The portion of the capsule thus attaching the cartilages to the tibia is known as the coronary ligaments, and fibres stretching between the anterior convexity of the two cartilages has been described as the transverse ligament. The knee-joint is of the hinge type with complimentary gliding and rotary motion. In extension, lateral motion is prevented by the lateral ligaments, but in flexion this function is performed by the crucial ligaments. The angle at which the tibia joins the femur in extension, normally throws greater strain on the internal lateral ligament than on the external. The internal cartilage is much more intimately attached to the internal lateral ligament than is the external to the external lateral ligament. Rupture and displacement of the internal lateral ligament will therefore be much more likely to disturb the internal cartilage than would be the case with the external cartilage if the external ligament were injured. The normal lateral angle of the knee is such that the longitudinal stress produced by the weight of the body tends to separate the articular surfaces on the inner side of the joint. The circumference of the cartilage is attached to the internal lateral ligament and when this structure is torn the cartilage may be displaced inward and jammed between the articular surfaces. When the femur is displaced laterally on the tibia the condyles ride upward on the semilunar cartilages and thus serve to bring the crucial ligaments to a tension. In sprains of the knee the semilunar cartilages may be fractured or displaced. They may be found free in the joint or only partially detached. A portion of the cartilage may be fractured and partially or completely separated from the remainder. It may be folded upon itself and in cases of long standing various degenerative changes have been noted in the entire joint as well as in the cartilage. Cases are on record in which the cartilage from one side of the articulation has been found on the opposite side of the joint cavity.

Symptoms.—In the typical case the clinical picture is quite characteristic. The patient gives a history of having been taken with severe pain in the knee (usually on the inner side) while the joint was partly flexed and under strain. The joint locked, so that he was unable to extend the leg, though it may have been possible for him to hobble some distance with the knee in a position about half way between complete extension and semiflexion. By repeated attempts at flexion and extension or with medical aid something was felt to give within the joint and the knee was again found to be free and capable of full extension.

Following the accident evidences of traumatic arthritis develop and the patient is confined to the house for a period varying from a few days to a few weeks according to the severity of the reaction. It is during this time that the surgeon usually first sees the case. If the patient gets about as soon as the swelling subsides recurrence of the accident is almost sure to occur when the knee is subjected to similar strain and position. The reaction following subsequent luxations is usually less severe than that attending the first displacement. In the atypical case there may be no history of the knee having locked. The patient may complain only of a sense of insecurity in the joint and of pain under strain, at times. In old cases the only evidences of the condition may be found in secondary changes such as chronic hypertrophic arthritis. For a number of days following the accident it is the rule to find tenderness in the region of the cartilage, usually the internal, and in some instances a gap between the bones may be produced by manipulation. Pain may be referred to the patella rather than the region of the cartilage though the tenderness is always more pronounced at the site of the cartilage. The absence of physical signs, however, is characteristic following the traumatic reaction. When the condition

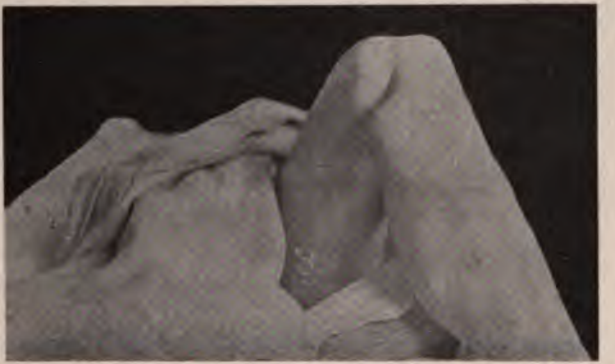

Fig. 656.—Subluxation of the knee with lateral dislocation of the patella. The internal lateral ligaments are torn and the semilunar cartilage displaced toward the spine of the tibia.

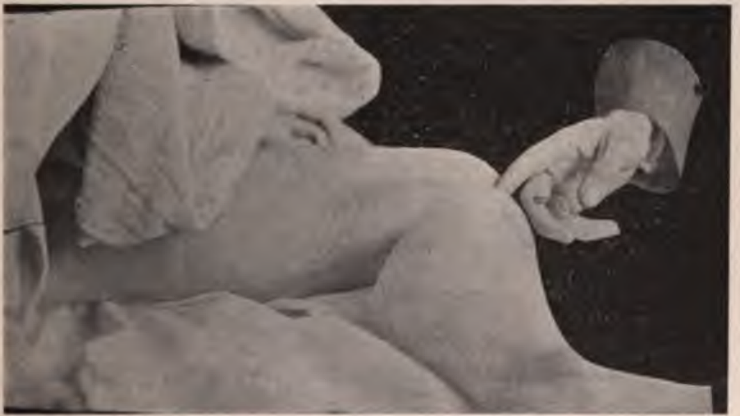

Fig. 657.—Another view of the same case showing how the finger may be inserted between the tibia and femur.

becomes recurrent it is not infrequently quite disabling. The time consumed in recovering from the traumatic reaction and the sense of insecurity which the patient experiences during the intervals are important sources of disability. The fact that the knee may be thrown out of function at any time deters him from many activities. The degenerative changes which so often follow in the articulation are important.

Diagnosis.—With the typical history of sudden pain and "locking" of the joint, with complete release of the articulation when the cartilage is reduced, the diagnosis is easy. In atypical cases, however, without the characteristic symptoms of locking of the knee, it may be impossible to arrive at a diagnosis until the joint is explored. It might seem that a diagnosis should be made in all cases, yet experience will show that mistakes are common even among those most thoroughly versed in the internal derangements of the knee. When the case is not typical the condition must be differentiated from: dislocations of the patella, synovial fringes, joint mice, lipomata and subluxations of the knee.

If the patient is seen during the acute disability there will be little difficulty in differentiating lesions of the semilunar cartilages from luxations of the patella. If, however, we are obliged to rely on the history given by the patient it may become an extremely difficult matter to arrive at a diagnosis. If the patella has been dislocated the region of the knee cap will be tender for a few days following the displacement and it is often possible, especially under anesthesia, to displace the bone beyond its normal limits. Moreover the characteristic tenderness on the inner side of the knee at the site of the semilunar cartilage is absent. If the case is seen some weeks or months following the accident it may be impossible to determine the conditions that existed, if the patient gives the usual imperfect history. When synovial fringes are pinched, the locking is not as pronounced and solid as occurs in luxations of the semilunar cartilages. Moreover the point at which the motion of the knee is interfered with is not constant and the pain is usually more intense and acute than occurs when the semilunar is at fault. When joint mice are present it may be possible to palpate one or more of the loose bodies within the articulation, and the point at which the action of the knee is interfered with varies with different attacks. If the disturbance in function is due to lipomata the acute symptoms are less severe and the subsequent acute traumatic arthritis is usually negligible. In addition a permanent puffiness is usually noted on either side of the patellar ligament which represents the enlarged fat pad beneath the ligament. In subluxations of the knee the history of trauma and the abnormal mobility will usually clear the diagnosis. The joint cavities have been injected with hydrogen and the X-ray used to determine the outlines of the semilunar cartilages but this method of diagnosis is seldom indicated in general practice. When it is employed the dangers of infecting the articulation should be kept in mind. In chronic disturbances of the knee the important points to be determined are whether or not the disturbance in function is sufficient to warrant opening the knee and whether or not good functional results can be obtained without operation.

Treatment.—If the case is seen while the cartilage is luxated, reduction should be effected at once. Reduction of the displaced cartilage is usually easy though cases are occasionally encountered in which open incision is necessary. Reduction is effected by acute flexion of the knee, the leg is then rotated back and forth on its axis and laterally deviated from side to side and finally extended. In acute flexion of the knee the most convex portions of the femoral condyles are in contact with the articular surfaces of the tibia and accordingly there is more room for the cartilages than when the knee is extended. This accounts for the release of the pinched cartilage during acute flexion. The rocking and rotary motions just described also tend to free the cartilage. If the surgeon flexes the knee over his wrist, the latter acts as a fulcrum and aids materially in separating the articular surfaces of the femur and tibia. If these manipulations have been successful and the cartilage has been freed, complete and active extension of the knee will be possible and painless. If they have failed the knee will be blocked just short of full extension and the patient will be unable to hold the leg extended in the horizontal position. Moreover the attempt will be attended by pain. The proof of reduction is the free active extension of the joint unattended by pain. The patient will almost invariably be able to state when the cartilage is reduced. His conduct reminds one of luxations of the shoulder in which the sufferer exclaims with satisfaction as the head of the bone slips back into the glenoid. The care of the case following reduction will be taken up in the after-treatment.

Operative Treatment.—The indications for operative treatment vary with the social state of the patient and the nature of the lesion. If this luxation occurs for the first time in a gentleman of leisure, who has ample time for non-operative methods and can avoid subsequent strain to the joint, the condition may be treated expectantly. If on the other hand the patient is a laboring man, whose time and activity mean his living, the cartilage causing the trouble should be removed at once. The advisability of operating following the first luxation is a question. If reduction is accomplished and the joint immobilized for a period sufficiently long to allow complete healing of the ligaments and cartilage, the condition may not recur. Cases of habitual luxation, with or without evidences of degenerative changes within the joint, call for operative intervention. Nothing can be expected from non-operative methods under these circumstances.

A vertical incision is made beginning about one inch behind the lateral border of the patella and a little above the horizontal plane of the articulation. This is carried downward across the articulation and continued backward in a curved direction as soon as the scalpel comes opposite the tuberosity of the tibia. After the skin incision is made the cutaneous edges are covered with gauze, which is held in position by tenaculæ. The tissues are then divided down to the capsule of the joint, which is incised with the least possible trauma. The half of the joint cavity to be operated upon is then open for inspection and the nature of the lesion may be determined. *The most rigid asepsis should be observed;* the gloved fingers should not be introduced within the articulation and instruments having come in contact with the hands should not enter the cavity. Sponges should be used but once. If the cartilage is fractured, detached (partially or completely), folded upon itself or degenerated it should be removed. Anchoring of the cartilage to prevent luxation should not be attempted as the results are not satisfactory. Removal of the cartilage should be accomplished with as little trauma as possible. If other derangements are encountered within the articulation they should be corrected. Following operation the joint should be immobilized and an ice cap applied to the knee to control any traumatic arthritis which may develop.

After-Treatment.—The care of the case following non-operative reduction consists in immobilizing the knee on a posterior splint in complete extension. Elevation of the lower extremity and the use of the ice cap will tend to control the traumatic reaction. If traumatic arthritis develops Buck's extension should be employed. Immobilization should be maintained for a period of three weeks and the resumption of function should be gradual. Strain to the knee in the flexed or semi-flexed position should be avoided for three or four months. If the inner side of the sole of the shoe is built up and the patient forms the habit of "toeing in" in walking, much of the strain will be removed from the internal lateral ligament and thus the chances of recurrent luxations of the internal semilunar will be reduced. Following operation and removal of the cartilage motion may be begun at the end of ten days and the patient may return to work within two weeks if there are no complications.

Prognosis.—Fracture or dislocation of a semilunar cartilage may occur only once if proper immobilization has been carried out following the accident. If on the other hand function is resumed immediately or as soon as the traumatic arthritis has subsided, recurrence is almost sure to follow. Restoration of function following operation is prompt and complete. The patient is able to resume his original occupation or to follow the sport in which the injury was sustained.

CHAPTER XLI.

FRACTURES OF THE PATELLA.

Surgical Anatomy.—The patella is a sesamoid bone developed in the tendon of the quadriceps extensor femoris. It is usually ossified from one center, which makes its appearance about the third year. In rare instances it is developed from two centers, laterally placed. The patella is attached to the tubercle of the tibia by the ligamentum patellæ, which maintains the bone at a constant distance from the tibia. The anterior surface is subcutaneous except for the prepatellar bursa which is interposed between the bone and the skin. The patella is covered on all sides, except the articular surface, by the tendon of the quadriceps which is spoken of below the bone as the ligamentum patellæ. In extension of the knee the articular surface of the patella is in contact with the trochlear surface of the femur; in flexion, with the condyles. The lower portion of the patella or apex has attached to it, both anteriorly and posteriorly, the fibres of the ligamentum patellæ.

The patella is situated in two fibrous planes; the superficial one is represented by the fascia lata covering the quadriceps extensor, the deep plane is the capsule of the knee-joint. When fracture occurs separation of the fragments does not take place unless the fascial planes, in which the bone is situated, are torn. The function of the patella is to afford leverage to the tendon of the quadriceps, while acting across the flexed knee. The insertion of this muscle is chiefly into the patellar ligament, but it should not be taken for granted that the quadriceps acts only through the patella, since it finds a broad insertion into the upper end of the tibia through the fascia lata and capsule. In instances, therefore, in which the patella is fractured without tearing of the fasciæ on either side of it, the patient still retains some power in extending the knee.

The mechanism of fracture of the patella has been the subject of considerable discussion, and even at the present time differences of opinion exist concerning it. The bone may be broken by direct violence, or by muscular action. When the former is the cause the fracture is often stellate or irregular and comminuted, depending upon the nature, direction and degree of the trauma. In this type of fracture the lateral fasciæ are seldom torn and the displacement is slight. Fracture produced in this way sometimes results in injury to the underlying articular surface of the femur. When fracture results from muscular action it is caused by the violent action of the quadriceps extensor on the patella while the knee is flexed. In this way the patella is broken across the condyles of the femur, and if the muscle continues to act, the fragments are separated and the lateral fasciæ torn.

The mechanism of fracture of this bone, as a result of muscular action, may be illustrated by the facility with which a stick can be broken across the knee when it will be impossible to part this same stick by simple traction and counter-traction in its long axis. If a blow is sustained on the flexed knee (either by a moving object or in a fall) while the muscle is contracting, the fracturing effect of the muscular pull is greatly increased. The upper end of the bone is fixed by the quadriceps and the lower end by the ligamentum patellæ, while the middle of the posterior surface is the only part of the articular face in contact with the femur during flexion. The distribution of these three forces explains the manner in which the patella may be snapped.

Fracture of the patella nearly always enters the knee-joint, but when confined to the lower portion of the apex of the bone, which is covered by the patellar tendon, the joint is not necessarily opened.

Etiology.—Transverse fracture of the bone is most common, while the comminuted form is next in order of frequency. Over four-fifths of all fractures of the patella are in the lower half of the bone. This accident occurs more often between the ages of thirty and forty, and is three times as common in males. Muscular action is probably responsible for more cases than is direct violence, although a combination of these two elements is not at all uncommon.

Symptoms.—Local pain is constant, with partial or complete loss of extension at the knee. The patient is sometimes able to walk backward by dragging the foot and keeping the knee hyperextended. If weight is put upon the leg, with the slightest degree of flexion at the knee, the lower extremity buckles and the patient falls. The condition is usually simple, although in severe crushing or cutting injuries the fracture may be compound and the joint exposed. Crepitus may be elicited in the absence of separation, or if the parted fragments are drawn toward each other and the serrated surfaces rubbed together. Some degree of separation is usually present, which in many instances can be detected by inspection alone if the case is seen before the parts become extensively swollen. It is often possible to lay one or two fingers in the depression existing between the fragments. Swelling and distention of the joint follow rapidly, and obliterate the depression be-

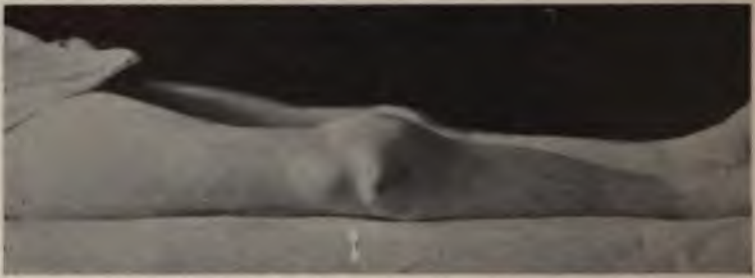

Fig. 658.—Old fracture of patella with separation of fragments. Recent fracture of the femoral neck, which accounts for the complete eversion of the entire lower extremity. The front of the knee looks outward instead of upward and the depression between the fragments of the patella is just above the point of the arrow.

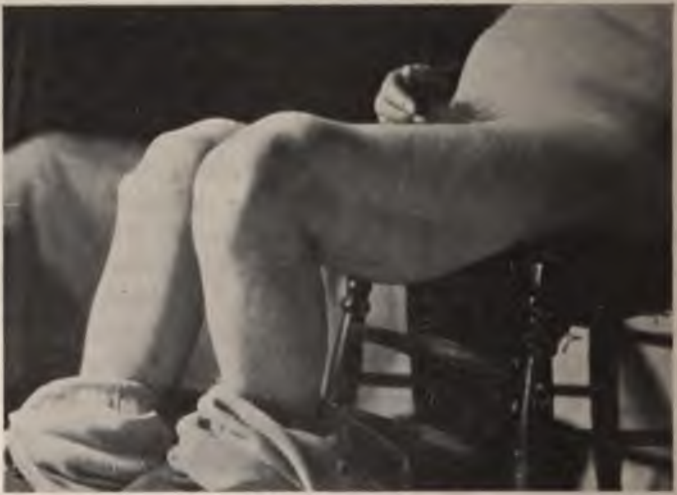

Fig. 659.—Shows an unusual case of fracture with wide separation of both patellæ. The fracture of the left patella is of three years' standing while that on the opposite side is two years old. Case treated by the expectant method which resulted in fibrous union with subsequent separation of the fragments. Case first seen by the author three years after the first fracture.

tween the fragments so that the condition cannot be recognized by inspection, although there is usually little difficulty in determining the deformity by palpation. The development of ecchymosis within twelve or twenty-four hours of the injury is the rule. It is usually most pronounced on either side of the patella corresponding to the positions of the lateral fascial tears.

The symptoms of acute traumatic arthritis generally supervene within a few hours of the injury. Swelling, redness, pain, tenderness and distention of the joint are present. When the joint becomes filled, the fluid reaches the surface between the fragments and produces a prominent swelling anterior to the patella. Distention of the joint cavity causes the patient to assume a characteristic position of slight flexion of the knee and moderate eversion of the thigh. The later symptoms of fracture of the patella depend largely upon the line of treatment followed. Pain, swelling and tenderness are usually not severe at the end of a week or ten days, especially if measures have been instituted for their control.

Bony union seldom occurs in cases which have been treated by non-operative methods and the amount of impairment in function will depend largely upon the length and strength of the fibrous union. This fibrous tissue tends to stretch with the subsequent use of the member, so that it is not uncommon for the patient to present himself for treatment at the end of a year or two because of pronounced and increasing loss of function. The separation between the fragments may be four or five inches or even more, so that the quadriceps extensor can be well contracted while the knee is still in a position of semiflexion. Secondary separation of the fragments is not prone to occur if the lateral fasciæ were untorn at the time of injury. Fibrous adhesions or bony union between the articular surface of the patella and the femur, may so fix the knee cap that the thigh muscle cannot move it, thus producing loss of function of an entirely different character.

Diagnosis.—The diagnosis is based on the history of injury to the knee followed by prompt loss of function and other symptoms just enumerated. Little difficulty should be experienced in recognizing the condition by inspection and palpation regardless of whether or not separation of the fragments exists. Even though the bone is superficial and easily palpated, nevertheless it is advisable to have an X-ray taken to accurately determine and record the details of the fracture.

Treatment.—The fact that reduction of the separated fragments is indicated in the treatment of fracture of the patella, is uniformly conceded, but the proper method of attaining this end has been, and is, the subject of much discussion. Even at the present time few surgeons agree concerning the best method of procedure. Some are opposed to opening the knee-joint as long as there is a fair prospect of obtaining some kind of a functional result by non-operative methods. Others take the position that every fracture of the patella should be subjected to open treatment if the general condition of the patient will permit of operation. Personal experience and observation have indicated that by far the best results follow the more radical measures. It is a well known fact that excellent functional results are sometimes seen in instances in which wide separation and heavy fibrous union are present. But on the other hand the highest percentage of functionally perfect results is seen in cases in which accurate anatomic reduction has been accomplished. Conclusive deductions cannot, at the present time, be

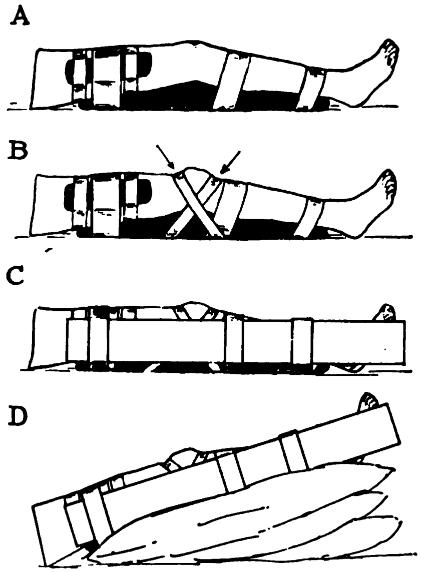

Fig. 660.—Shows the non-operative treatment of fracture of the patella. *A*. shows the lower extremity fixed on a posterior splint with the knee in a position of slight flexion. The splint is a straight splint heavily padded opposite the knee. Two short splints are secured to the thigh on either side of the quadriceps to prevent contraction of this muscle. *B*. shows diagonal strips of adhesive applied above and below the patella to approximate the fragments. *C*. shows lateral splints applied. *D*. shows the lower extremity raised on pillows to relax the quadriceps.

drawn from the statistics of operated cases because of the widely varying and sometimes imperfect technique which has been followed by different operators. In the author's opinion, non-operative treatment is only indicated in old and feeble persons, or in cases in which separation does not exist. The lack of proper surgical facilities and skill or the presence of certain constitutional diseases, such as diabetes, will of course act as contraindications to the open treatment. The first indication in the treatment of fracture of the patella, in both the operative and non-operative methods, consists in putting the lower extremity at rest and in instituting measures to control the traumatic arthritis. The lower extremity should be placed upon a posterior splint, which is secured in position by bandages and strips of adhesive as shown in Fig. 660. A snug bandage should cover the knee to control the swelling, and an ice cap to the parts will be found of great service in relieving pain and modifying the inflammatory reaction. If the expectant method is to be followed adhesive straps above and below the patella are diagonally placed in such a manner as to draw the fragments together (see Fig. 660). It is useless, however, to attempt to approximate the fragments until the joint distention has

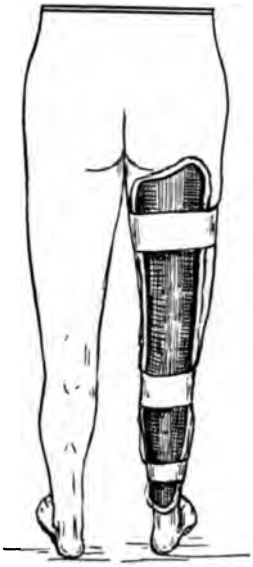

Fig. 661.—"Shaped" ham splint with padding applied to posterior aspect of lower extremity and held in position by three strips of adhesive plaster.

subsided, which will not be sooner than one week following the injury. There is no method of applying these straps, even after the fluid has left the joint, which will accurately approximate the fragments if separation has existed, notwithstanding statements to the contrary. This fact may be conclusively demonstrated by the use of the X-ray in any given case in which the fragments are supposed to have been reduced. In the rare instances in which fracture has occurred without separation of the fragments, as indicated by the X-ray, this method may be counted upon to give a good result. In most cases of fracture of the patella considerable separation will be found after everything which is possible in a non-operative way has been accomplished, and we therefore turn to the open treatment to secure reduction.

Operative Treatment.—The open treatment of fracture of the patella is the ideal method, but should not be attempted unless one fully appreciates the untoward possibilities, and is thoroughly equipped to carry it through. If the cases, in which unsatisfactory results have followed the open treatment, are analyzed, they will be found to have resulted from one or more of three conditions, namely: infection, insecure fixation of the fragments and prolonged immobilization of the knee.

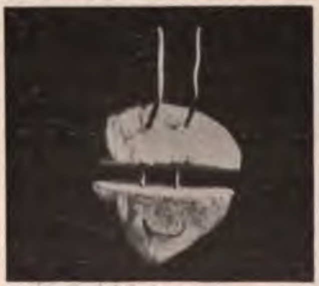

Fig. 662.

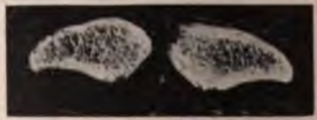

Fig. 663.

Fig. 662.—Shows the method of placing the silver wire mattress suture in approximating the fragments in a transverse fracture of the patella.

Fig. 663.—Shows a horizontal section of the patella at the same level. Note the relative distribution of cancellous and compact tissue.

Asepsis should be perfect in every detail as described under "Open Treatment of Fractures" on page 754. Infection following operations on the knee means not only failure in union, but involvement of the knee-joint which may result in loss of function in the articulation, if not amputation or death. It is common to find a clot of blood in the joint behind the fracture, which should be removed before the fragments are brought together. It is dangerous to leave this dead blood where it may favor subsequent suppuration (see "Open Treatment of Fractures," page 754). The

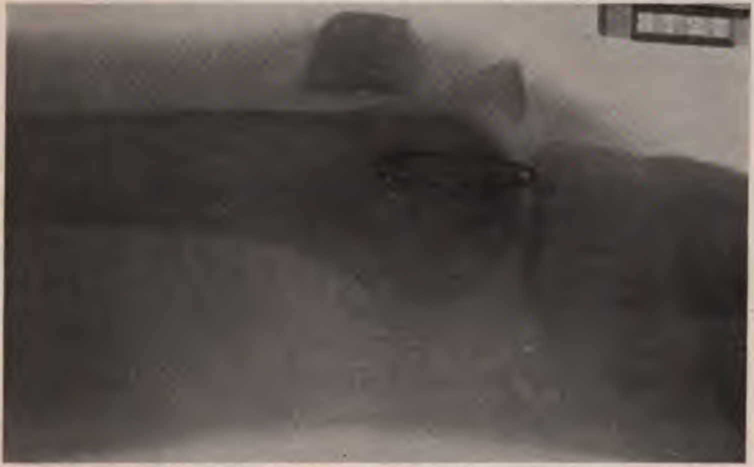

Fig. 664.—Recent fracture of the patella with separation of fragments. This is as near as the fragments could be brought together by non-operative methods.

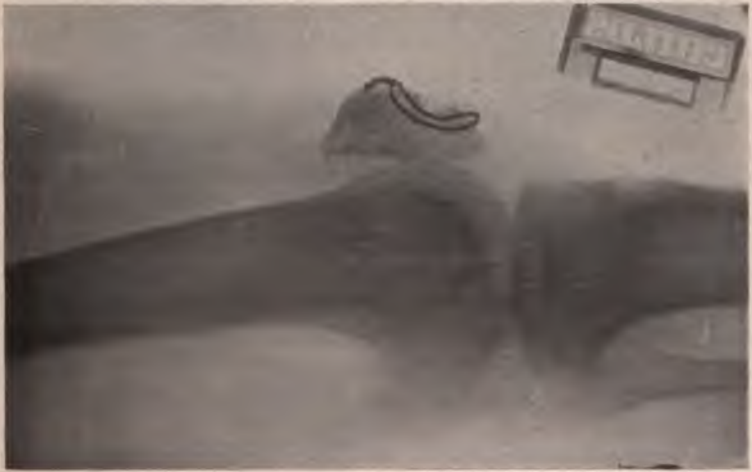

Fig. 665.—Same case after operation. A silver wire, mattress suture draws the fragments into apposition and holds them firmly against the displacing action of the quadriceps. Ultimate result, complete restoration of function.

fragments should be accurately and firmly approximated at the time of operation and so fixed that separation cannot take place during the after-treatment. Wire properly placed is the only material which can be counted on to secure proper and permanent immobilization. Absorbable suture material has been strongly advocated and good results may follow its employment; but the insecurity resulting from its softening and absorption before the end of the third week should condemn its use in fracture of the patella. It has been used in suturing the fasciæ covering the patella and in the repair of lateral fascial tears as well as in direct suturing of the bones through drill holes. Separation of the fragments is likely to occur during the second or third weeks, which can only mean failure in bony union with the possibility of further separation through stretching of the fibrous tissue. Even if chromicised catgut or other absorbable material could be counted on to maintain reduction until bony callus relieved it of strain, we could not rely on the sutured fascia to withstand the pull of the quadriceps during this period. It is apparent, therefore, that wire, securing a firm hold directly on the bony fragments, is the most satisfactory method of fixation. The structure of the patella should be remembered while securing the fragments. The wire should be so placed that it obtains its hold on the compact shell, rather than on the internal cancellated tissue, which is likely to give way under strain and allow the loop of wire to tear out. This is best accomplished by a mattress suture of wire as described later on. The more secure the internal fixation, the safer is the early employment of passive motion; and early passive motion is most essential in reestablishing the function of the joint. Its proper use will be described in the after-treatment. Loss of function and "painful joint" sometimes occur in cases in which proper reduction and bony union have followed the injury. These conditions are almost entirely due to the lack of early passive motion. The joint should be moved not later than two weeks from the time of operation, but passive motion has its risk, if fixation of the fragments is not solid, and should not be attempted without properly guarding the patella from the action of the quadriceps.

The following technique in operating on fractures of the patella has proven the most satisfactory in the author's hands and may be considered the procedure of preference in most cases. An incision is made exposing the fragments; it may be longitudinal and directly over the fracture or of the U-shape commonly employed in operations on the knee. With the fragments exposed and separated the clot which is usually found behind the fragments is removed with thumb forceps. Bony contact is essential and if fascia is found covering one of the fractured surfaces (usually the lower) it should be carefully removed before the fragments are brought together. In transverse fracture of the patella holes are drilled in each fragment so that the drill enters the anterior face of the patella and comes out on the fractured surface. Two such parallel holes are drilled in each fragment so that the openings on the fractured surfaces are opposite the corresponding openings of the holes on the other fragment. A heavy silver wire is then threaded through these holes so that the two ends are above the line of fracture (see Fig. 662). The fragments are then drawn together until they are in firm apposition and then the ends of the wire are twisted together, cut off, and turned in toward the bone. This mattress suture will securely hold the fragments in simple transverse

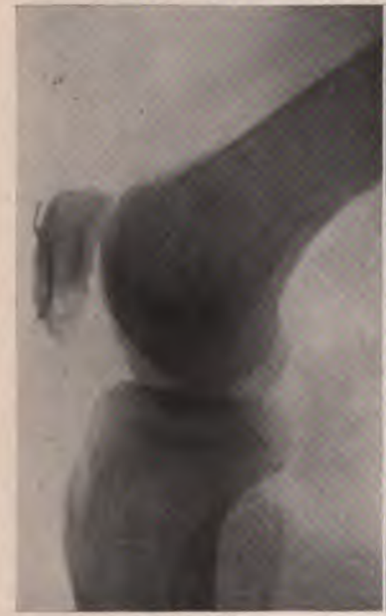

Fig. 666.

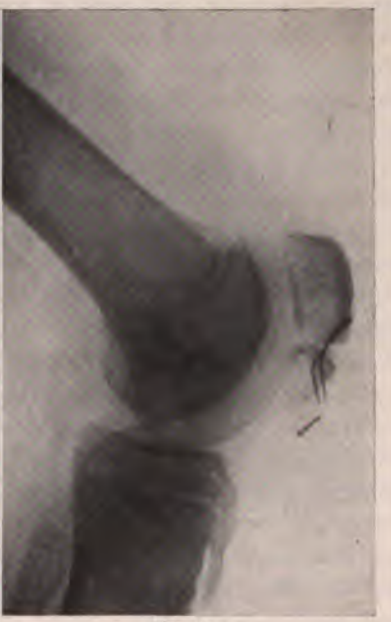

Fig. 667.

Fig. 666.—Wired fracture of the patella three years after injury. Function as good as before accident. Note silver wire which crosses line of fracture twice but does not enter joint. Accident in 1905; wire in place at the present time.

Fig. 667.—Wired fracture of the patella two years following accident. Patient failed to follow instructions, got out of bed and walked about shortly after operation with the result that the wire was broken. It held, however, sufficiently well to secure a functionally perfect result. This case demonstrates the advisability of using heavy wire which is as well tolerated by the tissues as lighter material. Compare this case with the one shown in Figs. 665 and note the size of the wire.

fracture of the patella and in addition may be made to work well when three fragments are present instead of two. In the presence of comminution it may be impossible to make the mattress suture hold because of the breaking up of the compact tissue, and when such is the case a circular wire surrounding the comminuted bone may serve the purpose. A specially formed Lane plate has been devised to be used on the patella but the nature of the bone and the difficulty of making the screws hold, results in wire being the material of choice in the open treatment of this fracture. When the wire is placed there should be no motion in the fragments nor in the wire: in other words the fixation should be as secure as possible, to obtain the best results. The knee should be flexed and extended before the wound is closed to see that the action of the joint does not disturb the fixation. The skin incision is then closed and a few strands of silk-worm are left in the lower angle of the wound to allow the escape of fluids following operation. If the vertical incision is employed directly over the fracture, a subcutaneous running suture should be so placed that it will bring as much of the soft tissues between the fracture and the skin as possible.

Fracture of the patella is sometimes compound from the first, with the joint exposed and infected at the time of the accident. When such is the case, the condition of greatest importance is infection of the knee-joint. This is a serious matter and if not properly controlled may necessitate amputation, or may even result in death from a general sepsis. The opening of the joint should be increased in size if not already sufficiently large, and the edges of the wound should be trimmed away until all traces of crushed and devitalized tissue are removed. The joint should then be irrigated with a few gallons of warm physiologic salt solution. In irrigating the wound a soft rubber catheter should be used, and carried to the innermost recesses of the articulation so that the flow will be directed from the interior of the joint to the surface. After the articulation has been thoroughly washed out, the soft tissue should be accurately approximated and the joint closed as tightly as possible with the idea of preventing subsequent leakage. The cavity of the knee is then injected with Murphy's Formalin Glycerine solution, the patient put to bed, the lower extremity elevated, Buck's extension applied and an ice cap kept on the knee. Subsequent injections of the formalin glycerine solution are made according to the amount of leakage through the incision and the reaction occurring in the articulation. This method of treating infected joints, devised by Murphy, is productive of such vastly better results that no other form of treatment should be considered until after this has been tried. If suppuration of the joint can be avoided in this way, suturing the patella may be done at the end of two or two and a half weeks when the dangers of articular infection have passed.

Suturing of the patella immediately following the accident should not be done in compound cases. The joint infection should be treated first and the fracture reduced in a secondary operation. If infection of the joint cannot be controlled by the initial irrigation and subsequent injection, it should be opened and freely drained, and under such circumstances approximation of the patella will be of little importance, since ankylosis of the knee-joint will, in all probability, be the result. If the accident occurs in a region of the country in which tetanus prevails, the patient should receive a prophylactic dose of anti-tetanic serum.

When operation is done for the secondary separation which sometimes follows fibrous union the method of procedure is similar to that already described. The fibrous tissue between the fragments should be excised and the fractured surfaces freshened and approximated. It may occasionally be necessary to lengthen the quadriceps above the patella to bring the fragments together. When the patella is attached to the trochlear surface by adhesions it may be possible to free it by forced passive motion under anesthesia. If the adhesions are too firm to be broken up in this manner it may be necessary to open the joint and divide them with the scalpel. If the adhesions are extensive and show a tendency to reform, a transplanted layer of fascia lata may be sutured in position to cover the articular surface of the patella. Early passive motion, repeated at regular intervals, will then, as a rule, result in a freely movable patella and good articular function.

After-Treatment.—The length of the after-treatment will vary according to whether or not the open method has been employed. If expectant treatment has been followed immobilization of the knee is required for from six weeks to two months, after which guarded passive motion is indicated. During the use of the splint the dressings should be carefully watched and tightened to keep them in proper position. The diagonal straps which tend to pull the fragments together are likely to become lax, especially as the joint distention subsides. During the first two or three weeks, pads should be kept on either side of the quadriceps and firmly bandaged in position to prevent contraction of this muscle. During the stage of articular inflammation the local application of the ice-cap will be found of service in controlling the reaction. The lower extremity should be elevated on an inclined plane to favor the circulation of the parts and relax the extensor thigh muscles. Accurate approximation of the fragments is practically impossible in the non-operative treatment, as previously stated, and during the time the joint is distended it will be useless to even attempt diminishing the degree of separation; when the fluid has left the joint the distance between them may be somewhat decreased by the proper application of straps. At the end of two months the splint may be discarded and the patient allowed to get about on crutches with some more convenient form of joint immobilization. A cast of the leg may be made, split up the front before thoroughly dried and removed. After the plaster is set the cast may be covered with some durable material and strips of leather with hooks, applied to the edges on either side of the opening. In this way the cast may

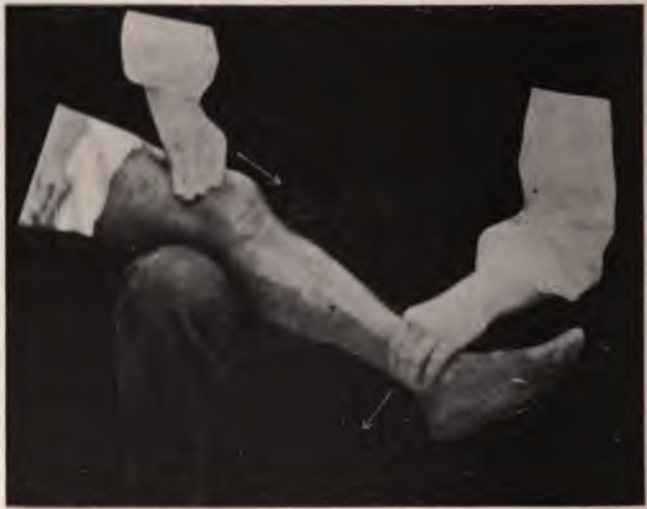

Fig. 668.—Method of performing passive motion in the treatment of fracture of the patella. The left hand bears down on the ankle thus flexing the knee while the right hand pushes downward on the patella to relieve the fracture of the pull of the quadriceps.

be removed at night for the purpose of massage and motion of the joint. During the day it is worn and when snugly laced immobilizes the knee and protects the patella from strain. Motion of the knee involving strain, such as walking without splint or cast, should be prohibited inside of from six to eight months. Exceptional muscular strain should be avoided for a year. If fibrous union is heavy and short, the time may be considerably shortened. If it is weak and shows a tendency to stretch, the period of fixation and protection of the knee should be increased.

The period of disability following the open treatment is strikingly shorter than that just described. The limb should be kept on a posterior splint as described in the after-treatment of unoperated cases. The dressings should be removed at the end of two weeks from the time of operation, and passive motion instituted, provided the internal fixation was properly and securely accomplished at the time the joint was opened.

The manner of performing passive motion is of considerable importance: the knee may be so flexed that the entire strain of the thigh muscles is thrown on the patella, or it may be so accomplished that the fracture is entirely relieved of the pull of the quadriceps. When the knee-joint has been fixed for a period of two or three weeks and the joint has suffered the inflammatory reaction incident to traumatic arthritis, it will be impossible to accomplish passive motion without producing spasm in the quadriceps, and it is this spasm which should be guarded against. If the surgeon places the lower extremity across his knee while one hand grasps the ankle and the opposite index finger and thumb are pressed into the thigh just above the upper border of the patella, he will be in a position to perform passive motion and still protect the patella from the spasmodic action of the quadriceps (see Fig. 668). As the ankle is depressed, thus flexing the knee, the opposite hand forces the patella downward towards the knee and takes up the strain of the contracting extensors of the thigh. This is the only way in which early passive motion can be performed without risk. Slight, snapping sensations are sometimes felt by the hand which forces the patella downward, but there is no cause for alarm since they are produced by the breaking up of adhesions in the joint which at this time are too imperfectly organized to act as serious obstacles to motion.

At the end of eight or ten weeks, the patient is allowed to get about without any fixation apparatus. It is well for him to carry a cane, and favor the injured knee for another two or three weeks, and he should be especially cautioned against unusual and excessive strains until four or five months have elapsed from the time of the injury. It is well to have another X-ray taken at the end of three months to determine the presence of bony union. The heavier the union, the less caution is necessary.

Prognosis.—The restoration of function following fracture of the patella is a variable quantity. Fibrous union, even to the extent of two or three inches, does not necessarily indicate that the patient may not enjoy most excellent function. On the other hand, accurate reduction and firm union does not necessarily indicate that the knee will be restored to its original usefulness. The percentage of functionally perfect results, however, is much higher in cases in which bony union is present. In the ordinary fractured patella we can hardly expect complete restoration of function with any form of non-operative treatment. The power of extension is likely to be decreased, and the action of the joint impaired, although it is not uncommon to find complete flexion possible. When fibrous union occurs, it will be impossible to state whether this union will be heavy, strong and efficient, or, on the other hand, thin, weak and permitting of subsequent separation of the fragments. Weakness and painful joint are common sequelæ.

The results following the open treatment are vastly better, provided the three requisites previously mentioned, are observed, namely: avoidance of infection, secure internal fixation of the fragments and early and persistent passive motion. Under such circumstances the usual result is complete and permanent restoration of function, together with absence of pain in the articulation.

CHAPTER XLII.

DISLOCATIONS OF THE PATELLA.

Surgical Anatomy.—There are a few anatomical facts bearing directly on dislocations of the patella, to be taken up at this time without entering into the details of the knee-joint, which were considered under fractures of the patella. The pull of the quadriceps is upward and in a direction parallel with the long axis of the femur. The ligamentum patellæ lies in the long axis of the tibia and since the axis of the tibia is not the same as that of the femur it will be apparent that the pull of the quadriceps (with the leg extended), is not in line with the long axis of the ligamentum patellæ. It is evident, therefore, that when the quadriceps contracts it not only pulls the patella upward but also tends to displace it outward. This tendency toward outward displacement of the patella is normally counteracted by the outer lip of the trochlear surface of the femur and the attachments of the capsule and fascia lata. When the capsule and fascia lata internal to the patella are lax, or when the outer lip of the trochlea is not sufficiently prominent, the bone may be displaced outward on violent contraction of the extensors of the thigh. The angle at which the tibia joins the femur varies considerably in different persons. It is usually greater in women because of the proportionately broader pelvis and greater divergence of the femora. The angle is greater in short stocky persons than in those of tall and slender stature. If the knee be fully extended and the quadriceps relaxed the patella will be found quite freely movable from side to side as well as vertically. If the lower extremity be kept in the same position and the thigh muscles tightened the patella immediately becomes fixed. This is due largely to the vertical groove in the trochlea and the corresponding ridge on the articular surface of the patella. It will thus be seen that although the quadriceps has a lateral displacing action on the patella, yet the contraction of this muscle also tends to prevent lateral displacement (if the fascial attachments and trochlea are normal) by forcing the patella into the groove on the trochlea. The muscles and fasciæ attached to the bone often tend to fix it in displacement after dislocation has occurred. The patella may be dislocated in any direction and is not uncommonly found rotated on its axis. If the patella is displaced laterally until it clears the trochlear surface, or the bone is completely rotated on its axis so that the articular face looks forward, the dislocation is said to be complete. If portions of the articular surfaces remain opposed or if the bone stands on edge the condition is incomplete and is spoken of as a subluxation. These distinctions are of degree only, and are more academic than practical. The same may be said of the classifications based on the details of the possible positions occupied by the patella during displacement.

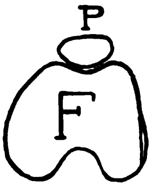

Fig. 669.

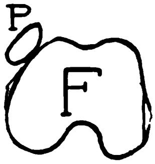

Fig. 670.

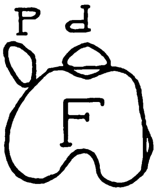

Fig. 671.

Fig. 669.—Normal relations between patella and lower end of femur.

Fig. 670.—Patella luxated outward. Most common type.

Fig. 671.—Represents patella displaced outward and "on edge." Also rotation of patella so that the posterior surface looks forward.

Etiology.—Luxations of the patella constitute less than one percent of all dislocations. Displacement may be in any direction although the external lateral type is by far the most common. The condition may be partial or complete. It is more common in women than in men; in short persons than in tall. Muscular action is often responsible for this luxation, although it may be caused by direct violence. A combination of these two elements is not uncommon.

Symptoms.—Sharp pain occurs at the time the bone is pulled or driven out of place, and unless spontaneous reduction occurs (which is not uncommon) there will be immediate loss of function with deformity which can be readily recognized both by inspection and palpation. Following the accident symptoms of acute traumatic arthritis develop although they are seldom as severe as those accompanying fracture of the patella. The deformity varies with the type of displacement. Recurrence of luxations of the patella are not uncommon and may constitute a most annoying and disabling condition. In many cases the patient will know just what position of the knee or what form of strain is productive of the displacement, and is always on his guard to avoid the condition while using the lower extremity.

Diagnosis.—If the surgeon sees the condition prior to reduction, he may recognize the displacement by the characteristic deformity. Palpation of the parts will readily determine, not only the fact that the patella is displaced but also, the type of luxation present. In instances in which the dislocation has been corrected or spontaneous reduction has taken place, it may be difficult to differentiate the condition from a fractured or luxated semilunar cartilage. A careful history and examination of the parts will usually result in determining which of the two conditions has occurred.

Treatment.—As a rule, little difficulty is experienced in returning the patella to its proper position. The knee should be maintained in complete extension, while the thigh is flexed on the abdomen to relax the quadriceps extensor. If the patella does not then slip back into place of itself, slight manipulation will usually suffice to reduce the luxation. Before manipulation is attempted the surgeon should have learned the relations of the displaced bone by palpation, so that he may cause it to retrace the course taken at the time of the accident. When the patella is found rotated on its vertical axis it is particularly necessary that the surgeon know in which direction rotation has taken place. This is readily determined by palpation of the muscle above, and the ligamentum patellæ below. It is extremely rare to encounter difficulty in reduction if the above manipulations be followed out, but should such occur, complete relaxation of the quadriceps may be had under anesthesia. In old, unreduced dislocations of the patella reduction may be impossible by ordinary methods, and under such circumstances it may be necessary to resort to open treatment.

Operative Treatment.—Reduction of recent dislocations of the patella by the open method is rarely necessary. In old luxations and in instances of recurrent dislocations operative treatment is often the only method which will give satisfactory results. In either of these conditions the bone may be exposed by a vertical incision or by the usual U-shaped incision. In old luxations it may be necessary to break up old adhesions and cut through scar tissue before the bone can be returned to its original position.

A number of methods have been advised and employed for the correction of recurrent dislocations. The tubercle of the tibia, with its attached ligamentum patellæ, may be chiseled off and reattached to the tibia, internal to its original position, so that the pull of the quadriceps is straightened, and the muscle thus loses its outward displacing action on the patella. Another method consists in plication of the internal portion of the capsule or in the repair of a rent, if one exists, thus securing the inner border of the patella so that it cannot be displaced outward by the pull of the quadriceps. Still another method consists in increasing the prominence of the outer lip of the trochlea by dividing it from the femur and displacing it forward. The first two methods are to be preferred to the last. In any of these operations the most strict asepsis is demanded, especially if the joint is opened.

After-Treatment.—Following reduction, the knee should be put at rest on a ham splint, and measures instituted for the control of the traumatic arthritis. Snug bandaging, and the use of the ice cap will usually be followed by subsidence of swelling within a few days. When the inflammatory reaction has passed, the knee should be strapped with surgeon's plaster to steady the patella, and the patient should be cautioned to avoid unnecessary strains. The position of the knee in which the luxation occurred is particularly dangerous.

Prognosis.—Dislocations, resulting from direct violence are likely to be followed by complete restoration of function, unless the trauma was severe and resulted in injury to the joint greater than that occurring in the ordinary patellar luxation. Dislocations resulting from muscular action are likely to recur at some later date. Recurrent dislocations are usually followed by good results if appropriately operated. In old unreduced dislocations restoration of function may be delayed or incomplete as a result of articular changes occurring while the bone was displaced.

CHAPTER XLIII.

DISLOCATIONS OF THE KNEE.

Surgical Anatomy.—In some of the lower animals the knee is composed of three distinct articulations. One between the outer tuberosity and the outer femoral condyle, another between the inner tibial tuberosity and the inner condyle of the femur and the third between the patella and the femur. In the human knee we have the analogues of these three joints although they are all merged into one. The crucial ligament attached to the inner condyle corresponds to the external lateral ligament of the inner articulation, and the crucial ligament attached to the outer condyle is analogous to the internal lateral ligament of the outer articulation. The knee-joint is the largest and one of the most complicated in the body. The proper apposition of the articular surfaces depends almost entirely on the ligaments holding the bones together, and when these structures are lacerated it will be necessary to allow sufficient time for them to become completely and firmly healed before the joint is subjected to any strain whatever. The ligaments binding the tibia to the femur are the posterior ligament, the internal lateral, the external lateral (divided into two parts), the capsule and the crucial ligaments. The two lateral ligaments limit lateral motion when the knee is in the extended position but are much less effective in this respect when the knee is flexed. In the flexed position the crucials perform this function. The posterior ligament limits extension of the knee. The anterior ligament, however, does not limit the flexion of the joint since it has no attachment on the femur. It serves simply as the insertion of the quadriceps, the tonic action of which muscle, acting through the tendon, helps to keep the articular surfaces opposed in whatever position the joint may be. The semilunar cartilages, and their ligaments (the coronary and transverse) are described under the heading of "Fracture and Dislocations of the Semilunar Cartilages," page 587. The ligamentum mucosum and alaria are simply reduplications in the synovial membrane and together with the crucials represent the division of the joint into two lateral halves, previously referred to. The bones entering into the formation of the knee-joint are long, and hence the leverage exerted against the ligaments of the joint is considerable. The articular surfaces of the tibia and femur conform to each other only poorly and the burden of holding these surfaces together rests entirely with the ligaments. The strength of these ligaments, however, is such that dislocations of the knee are extremely rare. It is more common for unusual strain to produce fracture than to tear the ligaments. Fracture produced in this way most often consists in the avulsion

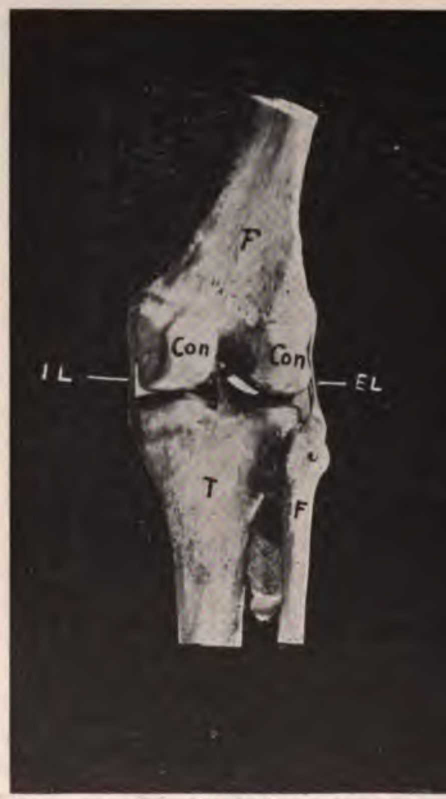

Fig. 672.

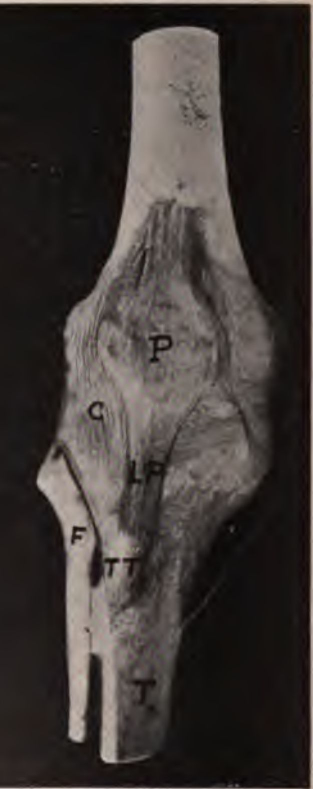

Fig. 673.

Fig. 672.—Ligaments of the knee. *I.L.*, Internal lateral ligament; *E.L.*, External lateral ligament; *F.*, Femur; *T.*, Tibia; *F.* (below), Fibula; *Con.*, Condyles. Between the two condyles may be seen the crucial ligaments.

Fig. 673.—Ligaments of the knee. *P.*, Patella; *T.*, Tibia; *F.*, Fibula; *L.P.*, Ligamentum Patellæ; *T.T.*, Tibial Tubercle; *C.*, Capsule.

of a small scale of bone corresponding to the insertion of the ligaments onto the tuberosity of the femur or tibia. In some instances, however, an entire condyle may be broken off by the pull of the ligament. With the knees extended and the heels together, the legs are parallel, while the femora diverge to include the pelvis between them at their upper ends. It is apparent therefore that the axes of the tibia and femur are not in the same straight line. This lateral angle at the knee results in greater strain being thrown on the internal lateral ligament, when longitudinal compression stress is brought to bear on the lower extremity. Accordingly rupture of this ligament is more common than rupture of the external lateral ligament. If the ligament is torn between the femur and the semilunar cartilage, the cartilage will remain attached to the tibia, which it will follow in displacement. If the tear is below the cartilage the reverse will be true.

The most common dislocation occurring at the knee is so slight as to scarcely deserve the term of subluxation. It consists in a tearing of the internal lateral ligament so that the leg may be deviated outward and the inner condyle and tibial tuberosity may be separated a slight distance. Dislocations of the knee are classified according to the direction taken by the tibia. Accordingly there are anterior, posterior, internal and external luxations of the knee. In addition there is another type of dislocation in which the tibia is rotated on the femur.

The relation of the popliteal artery directly behind the articulation is of importance as already described under ''Fractures of the Lower End of the Femur.'' The popliteal nerve situated somewhat more superficially in the popliteal space, and the peroneal nerve passing from behind the knee to the outer side of the leg where it winds around the head of the fibula, are sometimes injured in dislocations of the knee as evidenced by sensory and motor disturbances throughout their areas of distribution.

The most important motion in the knee-joint is that of the hinge type. In addition to this there is a slight gliding action between the femoral condyles and the tibia, and when the knee is flexed there is a slight rotary motion between the two bones. The hinge action takes place between the femoral condyles and the semilunar cartilages, while the gliding and rotary motion is between these cartilages and the tibia.

The antero-posterior luxations are more often incomplete than complete. Complete lateral luxations of the knee are extremely rare. The most common luxation is forward, and then in order of frequency, backward, outward, inward and rotary. Great violence is necessary to produce luxation of the knee. Probably the most common injury to the knee-joint consists in rupture of the internal lateral ligament with temporary separation of the articular surfaces on the inner side of the articulation.

Symptoms.—The accident is almost invariably the result of severe trauma and if the history of the case is elicited an idea of the degree of violence applied to the lower extremity at the time of the accident can usually be had. Pain, shock and loss of function are usually pronounced. Any of the luxations occurring at the knee may be complete or incomplete, simple or compound and complicated or uncomplicated by injury to vessels and nerves. The symptoms will vary according to the details of the case. Abnormal mobility is present. In complete luxations the action at the knee is usually flail-like and the percentage of cases in which the condition is compound is high. In a complete forward dislocation of the knee treated by the author amputation was necessitated by the complete severance of the popliteal artery, and following the operation the knee-joint was partially dissected for the purpose of ascertaining the condition of the injured structures. The two lateral ligaments, the posterior ligament and the crucials were completely ruptured. The inner head of the gastrocnemius and the popliteus were torn across. The femoral condyles projected through a large rent in the popliteal space and their lower surfaces were about two and a half to three inches below the level of the tibial articular surfaces. The popliteal artery was completely torn across and the ends separated shortly above the popliteal notch. The popliteal and peroneal nerves were also completely divided. The semilunar cartilages remained with the tibia. This type of case is extreme and demands immediate amputation above the knee.

It is more common to see an incomplete dislocation in which a portion of the femoral condyles remains in contact with the tibial articular surfaces. The loss of alignment in the axes of the femur and tibia is apparent. The forward displacement of the tibia is seen at a glance. The patella is less prominent than normal because of the forward displacement of the tibia. If the artery is compressed or divided, loss of pulse and lowering of temperature below the knee will be noted. If the artery is simply compressed, but not otherwise injured, the pulse will return with reduction of the luxation. Pain may be intense if the nerves are stretched or compressed; if divided, sensory and motor paralyses will be present. In compound cases with laceration of the artery, hemorrhage is usually not profuse, strange as it may seem.

In backward luxations the relations of the tibia and femur at the knee, are reversed. The lower end of the femur is prominent anteriorly while the posterior edge of the upper end of the tibia may be palpated posteriorly. If the luxation is complete the bones override in a manner similar to that described in the anterior form of luxation. The condition is much more likely to be compound when the luxation is complete. The femur may penetrate the skin anteriorly or the upper end of the tibia may be found projecting through a rent in the popliteal space.

The lateral luxations usually consist of either inward or outward incomplete displacement of the tibia. Complete lateral luxation of the knee is quite rare and the complications accompanying the condition are usually less important than those occurring in the antero-posterior types.

In the rotary form of luxation, which is extremely uncommon, the tibia is seen to have rotated on its axis so that the normal relations between the articular surfaces are disturbed. The rotation is seldom more than forty-five degrees and is more often outward than inward. The axis of rotation may pass through the outer or inner tuberosity or in the region of the tibial spine. The ligamentous structures ruptured will depend largely on the axis of rotation.

In the different luxations occurring at the knee any or all of the ligaments binding the tibia to the fibula may be ruptured or one of their attachments avulsed, according to the nature and degree of the dislocation. Avulsion of the tibial spine has occurred in lieu of rupture of the crucials.

Traumatic reaction is usually pronounced during the first week or ten days following the accident.

Function is completely lost in all forms of complete luxations of the knee. Active motion of the leg is sometimes only partially lost when the luxation is incomplete.

Treatment.—Traction in the long axis of the lower extremity with coaptation pressure on the displaced articular ends will usually suffice to reduce the luxation. A fragment of bone such as that produced by avulsion of the insertion of one of the lateral ligaments, may become interposed between the articular surfaces or a displaced semilunar cartilage may act as an obstacle to reduction. Continuous traction as exerted by Buck's extension may control a tendency toward recurrence of deformity and is otherwise of service if the traumatic arthritis proves severe.

Operative Treatment.—Operation is often indicated in cases in which the luxation is complete. If the circulation below the knee is destroyed amputation should be performed at once. One should be absolutely positive, however, that such is the case, before removing the leg. Simple compression of the artery will stop the pulse and circulation in the leg but with reduction and removal of pressure will be accompanied by the return of the pulse in the dorsalis pedis. It may be possible in some of the compound cases to directly examine the popliteal artery through the wound while the patient is on the operating table. When the artery is divided it is usually much lacerated and the ends retracted. In compound cases in which the circulation is not destroyed the wound should be thoroughly cleansed, the devitalized tissues trimmed away and divided structures approximated. Reduction of compound cases without these precautions is much more likely to be followed by infection and suppuration. (See "Treatment of Compound Fractures and Dislocations," page 789.) Open incision is sometimes called for to remove an obstructing fragment of bone or a displaced semilunar cartilage which interferes with reduction. The possibility of operative repair of ligaments should be given careful consideration in instances of recovery with loss of lateral stability of the knee-joint. The lateral ligaments are easily exposed through lateral incisions, but operation on the crucials is a much more difficult matter. The crucial ligaments are best exposed through a U-shaped incision dividing the ligamentum patellæ. The flap thus made is reflected and the knee flexed, so that the ligaments may be seen in the popliteal notch. Plastic operations may be needed to bring the ends of the ligaments together and considerable difficulty may be experienced in placing the mattress sutures because of the narrow limits of the popliteal notch. A small full-curved needle should be used. A needle may be heated in a flame and bent while hot to make the curve sufficiently sharp to meet the requirements. After repair of the crucial ligaments the knee should be protected from lateral strain for many months by wearing a brace.

After-Treatment.—Following reduction of a dislocation or subluxation of the knee the lower extremity should be immobilized on a posterior splint, the leg elevated on a pillow and carefully watched for evidences of stasis. If at any time during the after-treatment it is positively determined that the circulation has been destroyed the leg should be amputated. The general condition of the patient will often require careful attention during the first few days following the accident. If shock is great appropriate stimulants should be exhibited and when accompanied by much pain opiates may be necessary. The joint should remain fixed for a period of three months or more according to the extent of ligamentary laceration. Early use of the knee will usually be followed by instability of the joint and much loss of function. The repair of ligaments is often surprisingly complete if the proper time is allowed before the joint is subjected to strain. Massage, when the splint is removed and during the time the knee is immobilized is of great service in maintaining the tonicity of the thigh and calf muscles.

Prognosis.—The outlook in complete dislocations of the knee is not good especially if the condition is compound. The prognosis depends chiefly on the complications, the most important of which are injuries to the artery and nerves and the exposure of the joint to infection in compound luxations. If the case is incomplete and uncomplicated good restoration of function is the rule, provided sufficient time is allowed for the proper healing of the ligaments. Imperfect and incomplete healing of the ligaments may result in loss of lateral stability, sufficiently pronounced to require the use of a jointed knee brace. Surprisingly good function has been reported in a few cases of old unreduced luxations of the knee. If the knee-joint becomes infected following a compound luxation the prognosis will be that of a septic arthritis. In severe compound cases death may ensue from shock, thrombosis, embolism, septicemia, etc., unless prompt and radical surgical measures are instituted.

CHAPTER XLIV.

INJURIES JUST BELOW THE KNEE—FRACTURES OF THE TIBIA AND FIBULA (UPPER ENDS).

The injuries occurring in this region of the leg and to be considered under this heading are: fracture of the upper end of the tibia (either into or below the knee-joint), separation of the upper tibial epiphysis, fracture of the upper end of the fibula, separation of the upper tibial epiphysis and dislocations of the upper tibiofibular articulation.

Surgical Anatomy.—The broad, expanded, upper extremity of the tibia which forms the tuberosities, is largely subcutaneous and can be readily palpated just below the plane of the knee-joint. The inner tuberosity presents a horizontal groove on its posterior aspect for the insertion of a portion of the semimembranosus. The circumference of the tuberosity is taken up by the attachment of the capsule and the internal lateral ligament. In like manner the circumference of the outer tuberosity is taken up by the capsule on the outer side of the joint, but the external lateral ligaments of the knee are not attached to this bone but to the head of the fibula. The posterior aspect of the outer tuberosity articulates with the upper end of the fibula, and half-way between the tibial tubercle and the fibular head is inserted the lower end of the ilio-tibial band. The upper end of the tibia is composed of cancellous tissue which is encased in a thin layer of compact bone. The heavy compact tissue of the shaft grows rapidly thinner as the upper end of the bone is approached.

Fracture of the upper end of the tibia is the result of direct or indirect violence, usually the former. The line of fracture may be vertical, entering the joint cavity, or it may be transverse and below the articulation. Transverse fracture of the upper end of the tibia is usually the result of direct violence and the displacement is, as a rule, not great. The superficial position of the bone accounts for the frequency of compound fractures in this region, especially when produced by direct violence. When the fracture enters the joint it is usually the result of violent adduction or abduction of the leg. T-fractures however are usually the result of violence transmitted to the upper end of the bone in the long axis of the tibia. When this mechanism obtains in the production of fracture of the upper end of the tibia the shaft is driven upward into the upper fragment and usually splits it into two or more pieces. The upper fragment is sometimes extensively comminuted. This type of fracture is most frequently the result of a fall from a height in which the patient lands on the foot. In rare instances the shaft may be driven upward into the upper fragment without splitting the latter and the result is likely to be impaction with shortening of the leg, but no abnormal mobility, crepitus, etc. Most of the fractures of the upper end of the tibia entering the joint cavity are accompanied by spreading of the tuberosities. The action of the lateral ligaments in producing fracture of the tuberosities or of the femoral condyles has been described under "Dislocations of the Knee," and again under "Fractures of the Lower

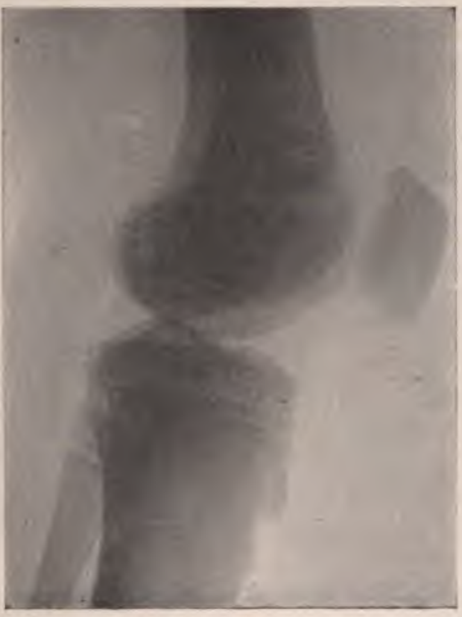

Fig. 674.—Lateral view of the knee before the epiphyses have joined the shaft. Note how the upper epiphysis of the tibia extends downward anteriorly to include the tubercle of the tibia. This formation is spoken of as the "lipping" of the upper tibial epiphysis.

End of the Femur." Fracture and avulsion of the spine of the tibia due to the pull of the crucials is a complication of dislocations of the knee, and has been mentioned under that heading.

The upper epiphysis of the tibia is ossified from a single center which makes its appearance soon after birth and joins the shaft at about the twentieth year. The epiphyseal cartilage corresponds roughly to a horizontal plane about one inch below the top of the bone. Anteriorly however it dips downward as it approaches the anterior border, to pass under the tibial tubercle. A not uncommon anomaly is for the tibial tubercle to be ossified by a separate center. This downward extension of the epiphysis to include the tibial tubercle is of importance clinically. The quadriceps extensor is attached to the tubercle through the ligamentum patellæ, and with violent contraction of this muscle the anterior part of the epiphysis (the tubercle of the tibia) may be partially or completely separated from the diaphysis. Complete separation of the tibial epiphysis is an extremely rare condition but a starting of the tubercle with a corresponding partial detachment of the epiphysis is not uncommon in youth.

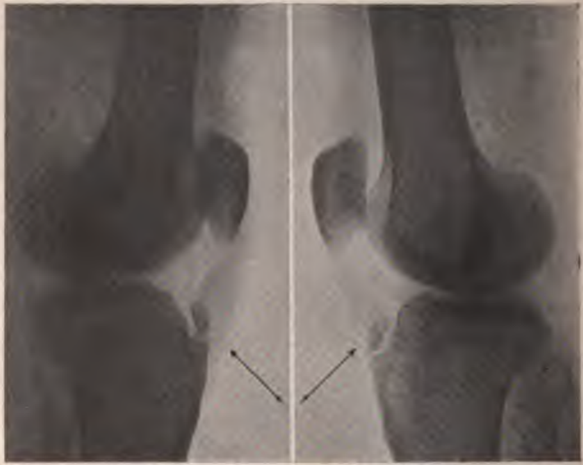

Fig. 675. Fig. 676.

Figs. 675 and 676.—An anomaly in the ossification of the upper end of the tibia which is likely to be mistaken for fracture of the tibia. A close examination of an X-ray plate (not print) will show the supposed fragment to be surrounded by a layer of compact tissue and the contour of ossicle does not correspond to the portion of the tibia from which it is supposed to have been broken off. Moreover this type of anomaly is almost invariably bilateral.

The upper extremity of the fibula does not enter into the forma-

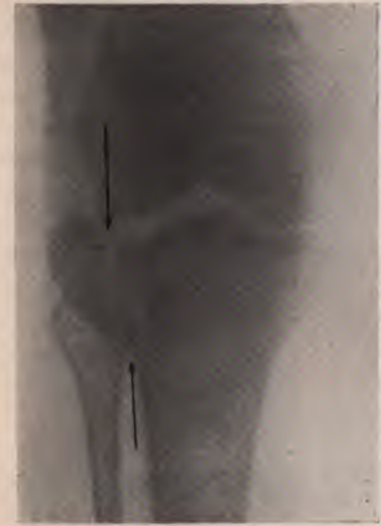

Fig. 677.

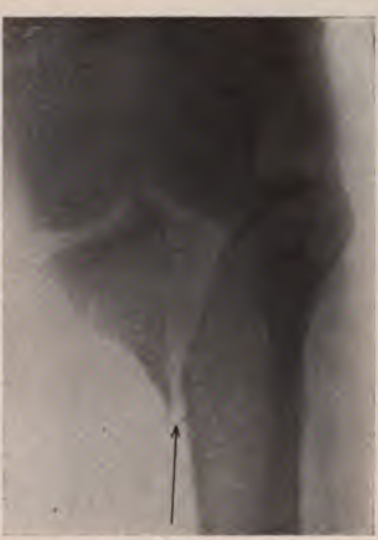

Fig. 678.

Fig. 677.—Vertical fracture of upper end of tibia.
Fig. 678.—Vertical fracture of upper end of tibia.

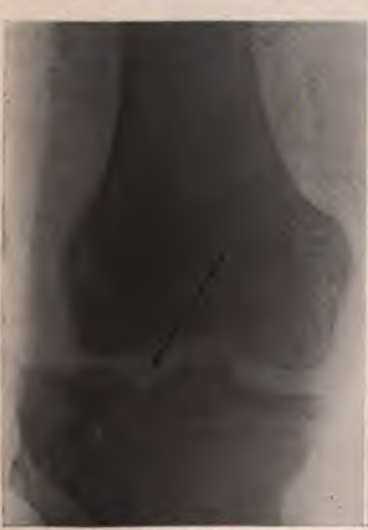

Fig. 679.

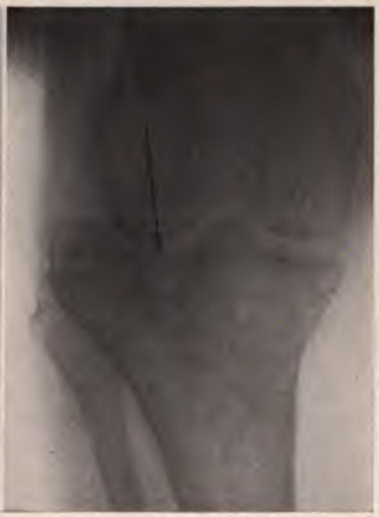

Fig. 680.

Fig. 679.—Fracture of upper end of tibia involving the external articular surface.
Fig. 680.—Splitting of upper end of tibia.

Vertical fractures of the upper end of the tibia such as those shown on this page are not uncommon, and if not accurately reduced considerable disturbance in joint function may result. Operative measures are frequently indicated to obtain the best results.

tion of the knee-joint, though the two external lateral ligaments of the knee are attached to it. The long head of the biceps (outer hamstring muscle) is inserted around the base of the styloid process, and the attachments of the soleus, peroneus longus and extensor longus digitorum are continued upward from the shaft onto the upper extremity of the bone. This epiphysis of the fibula begins to ossify about the fourth year and joins the shaft at about the twenty-fifth. Violent contraction of the biceps is known to have caused fracture of the upper end of the fibula, or separation of the epiphysis, and adduction of the leg has produced the same result through the pull of the external lateral ligaments. Fracture of the upper end of the fibula just below the head of the bone is usually the result of direct violence. Occasionally it accompanies fracture of the upper end of the tibia.

The upper tibio-fibular articulation is a simple arthrodial joint with very limited motion. The articular surfaces entering into its formation are flat and the integrity of the joint depends entirely on the strength of the ligaments holding the two bones together. This joint possesses an anterior and a posterior ligament which are thickenings in the capsule surrounding the articulation. Anterior and posterior displacements are prevented as long as the force is not sufficient to rupture these ligaments. Upward displacement is prevented not only by these ligaments but by the interosseous membrane and the lower tibio-fibular articulation. The importance of displacements of the upper end of the fibula depends mainly on the fact that the peroneal nerve winds around the neck of the bone and may be injured with direct violence to the outer side of the leg, or when the head of the fibula is luxated. This nerve can be felt beneath the skin behind the tendon of the biceps. It passes between the tendon of the biceps and the outer head of the gastrocnemius and then winds around the neck of the fibula. It passes forward to join the anterior tibial artery and gives off branches, as it passes down the front of the leg, to supply the extensors of the foot. Injury to this nerve is accompanied by foot drop.

Etiology.—Fractures of the upper ends of the tibia and fibula are usually due to direct violence. Forcible adduction or abduction of the leg may result in fracture of the tuberosities. Violence transmitted in the axis of the leg may produce fracture of the upper end of the tibia and fibula, although all forms of indirect violence are more likely to produce fracture below the middle of the shaft.

Symptoms.—Because of the variety of fractures which occur in this region, the symptoms seen in different cases vary considerably. The swelling and deformity which accompany simple transverse fracture of the upper end of the tibia may be remarkably slight. I have seen a number of cases suffering from this type of fracture in which the patient was able to bear weight on the leg. The disability, however, is usually complete. Abnormal mobility is almost invariably present although impaction of the lower, into the upper fragment, may result in the leg being quite firm. When the fracture is of the T-type or in instances in which one of the tuberosities is broken off, articular distention and traumatic arthritis develop rapidly. Under these circumstances the lateral stability of the knee is usually lost and abnormal lateral mobility is apparent as soon as the parts are manipulated. The leg may be adducted or abducted to an abnormal degree and this maneuver usually produces crepitus. In T-fracture of the upper end of the tibia or in fracture of one of the tuberosities, the tuberosities may be spread to such an extent that the condition is readily recognized by inspection alone. (See Figs. 681 and 682.) The parts below the knee are tender and painful. Fracture in this region, due to direct

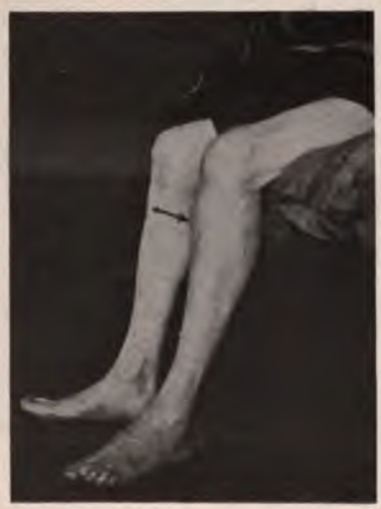

Fig. 681.—Fracture of upper end of tibia. Note thickening at point indicated by arrow.

violence, is often compound and if the line of fracture enters the joint it may be followed by suppurative arthritis.

Avulsion of the tubercle of the tibia is accompanied by a more or less upward displacement of the patella according to the extent of tearing in the lateral expansions of the aponeurosis of the quadriceps extensor. The loose detached fragment can be palpated without difficulty unless the swelling is intense. The ligamentum patellæ is abnormally lax. Rupture of the patellar ligament gives a similar symptom-complex except for the absence of the detached fragment of the tubercle.

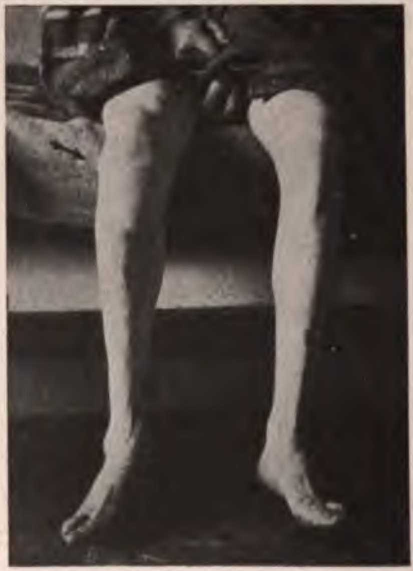

Fig. 682.—Longitudinal fracture of the upper end of the right tibia. Tuberosities spread so that finger may be pressed into external articular cavity just above prominence indicated by arrow. Such a fracture will interfere with the use of the knee-joint unless the fragments are brought together and held in place. Operation is usually necessary in this type of case to secure the best results.

Separation of the upper tibial epiphysis is attended by symptoms similar to fracture in this region. The epiphysis may be displaced in any direction. The crepitus produced by manipulation is soft and cartilaginous. The condition is extremely rare.

Fracture or epiphyseal separation of the upper end of the fibula is accompanied by local tenderness and pain especially when the leg is used. It is often possible to move the head of the bone about. Crepitus is usually elicited without difficulty. If the fracture is

through the tibio-fibular articulation or below it, pressure on the shaft of the bone, in the middle of the leg, will produce pain at the seat of fracture. Injury to the peroneal nerve will be productive of characteristic symptoms in motion and sensation throughout the distribution of the nerve. In luxations of the fibular head the upper end of the bone is more prominent than normal and its displacement either forward or backward is, as a rule, easily recognized.

Injuries to vessels and nerves are not as common in this region of the leg as they are in fractures of the lower end of the femur but when they do occur the same train of symptoms will become manifest.

Diagnosis.—There is, as a rule, little difficulty in recognizing fracture in this region. A simple transverse break, however, just below the tibial tuberosities, may, in rare instances, be difficult to determine without the aid of the X-ray. In the exceptional cases in which the shaft is impacted into the upper fragment without splitting the latter, abnormal mobility may be absent, but the condition should be recognized by the shortening of the leg, and in some instances there will be sufficient angular deformity to indicate the nature of the lesion. The X-ray is of the greatest value in determining the nature of the injury in the exceptional cases in which the physical signs are indefinite.

When the upper end of the fibula alone is fractured the patient may be able to get about, though the use of the member entails more or less swelling and pain. This fracture has not infrequently been overlooked in spite of the fact that pressure in the middle of the shaft is productive of pain at the site of the lesion, if the fracture is below or through the upper tibio-fibular articulation. If the fracture is above this level it should be recognized by direct palpation.

Treatment.—The desiderata in the treatment of these fractures are: reduction of deformity, immobilization of the fragments and restoration of function after the fragments have united. The details of treatment will vary with the type and severity of the fracture. In a simple transverse fracture of the upper end of the tibia, deformity is often slight and reduction easy. Strong traction on the leg with direct pressure over the displaced fragment will usually effect reduction. The fragments, however, are often so well apposed that nothing in the way of treatment is indicated aside from fixation. The lower extremity should be immo-

End of the Femur." Fracture and avulsion of the spine of the tibia due to the pull of the crucials is a complication of dislocations of the knee, and has been mentioned under that heading.

The upper epiphysis of the tibia is ossified from a single center which makes its appearance soon after birth and joins the shaft at about the twentieth year. The epiphyseal cartilage corresponds roughly to a horizontal plane about one inch below the top of the bone. Anteriorly however it dips downward as it approaches the anterior border, to pass under the tibial tubercle. A not uncommon anomaly is for the tibial tubercle to be ossified by a separate center. This downward extension of the epiphysis to include the tibial tubercle is of importance clinically. The quadriceps extensor is attached to the tubercle through the ligamentum patellæ, and with violent contraction of this muscle the anterior part of the epiphysis (the tubercle of the tibia) may be partially or completely separated from the diaphysis. Complete separation of the tibial epiphysis is an extremely rare condition but a starting of the tubercle with a corresponding partial detachment of the epiphysis is not uncommon in youth.

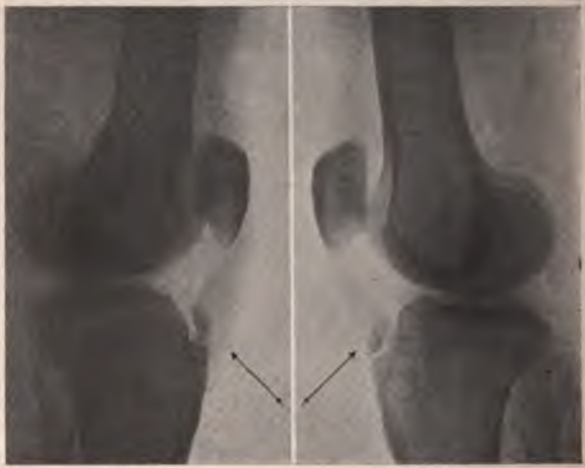

Fig. 675. Fig. 676.

Figs. 675 and 676.—An anomaly in the ossification of the upper end of the tibia which is likely to be mistaken for fracture of the tibia. A close examination of an X-ray plate (not print) will show the supposed fragment to be surrounded by a layer of compact tissue and the contour of ossicle does not correspond to the portion of the tibia from which it is supposed to have been broken off. Moreover this type of anomaly is almost invariably bilateral.

The upper extremity of the fibula does not enter into the forma-

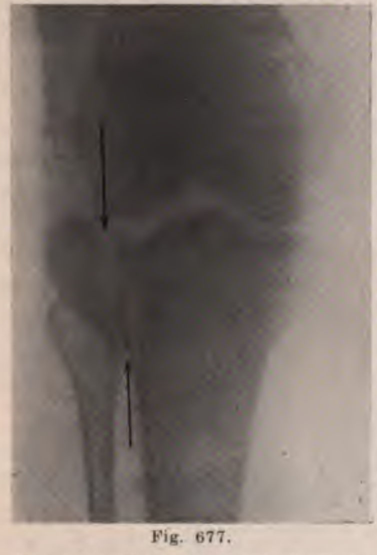

Fig. 677.

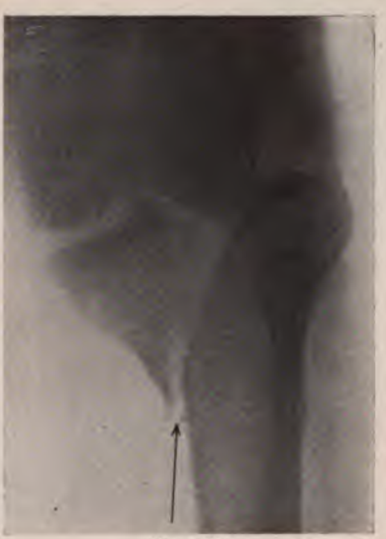

Fig. 678.

Fig. 677.—Vertical fracture of upper end of tibia.
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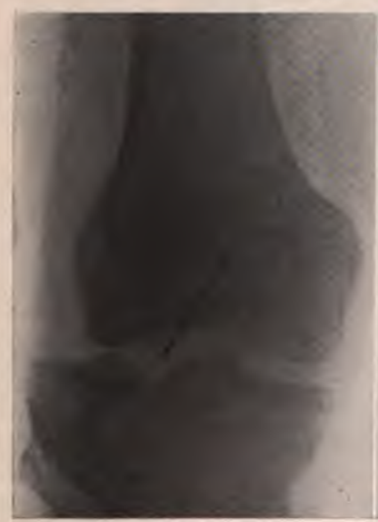

Fig. 679.

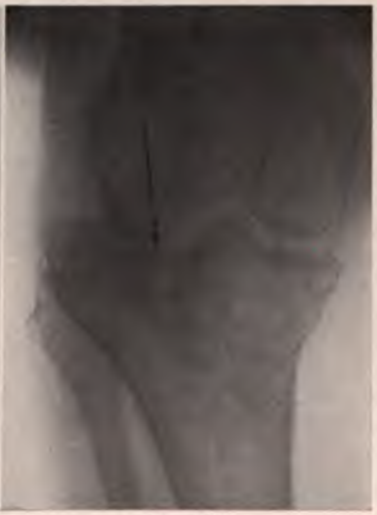

Fig. 680.

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Fig. 680.—Splitting of upper end of tibia.

Vertical fractures of the upper end of the tibia such as those shown on this page are not uncommon, and if not accurately reduced considerable disturbance in joint function may result. Operative measures are frequently indicated to obtain the best results.

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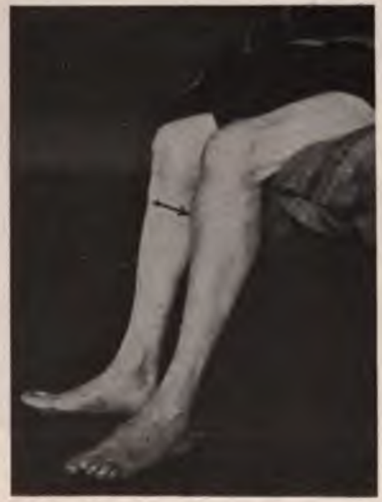

Fig. 681.—Fracture of upper end of tibia. Note thickening at point indicated by arrow.

violence, is often compound and if the line of fracture enters the joint it may be followed by suppurative arthritis.

Avulsion of the tubercle of the tibia is accompanied by a more or less upward displacement of the patella according to the extent of tearing in the lateral expansions of the aponeurosis of the quadriceps extensor. The loose detached fragment can be palpated without difficulty unless the swelling is intense. The ligamentum patellæ is abnormally lax. Rupture of the patellar ligament gives a similar symptom-complex except for the absence of the detached fragment of the tubercle.

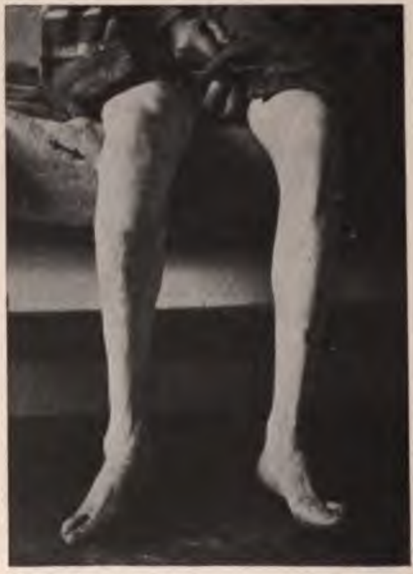

Fig. 682.—Longitudinal fracture of the upper end of the right tibia. Tuberosities spread so that finger may be pressed into external articular cavity just above prominence indicated by arrow. Such a fracture will interfere with the use of the knee-joint unless the fragments are brought together and held in place. Operation is usually necessary in this type of case to secure the best results.

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Injuries to vessels and nerves are not as common in this region of the leg as they are in fractures of the lower end of the femur but when they do occur the same train of symptoms will become manifest.

Diagnosis.—There is, as a rule, little difficulty in recognizing fracture in this region. A simple transverse break, however, just below the tibial tuberosities, may, in rare instances, be difficult to determine without the aid of the X-ray. In the exceptional cases in which the shaft is impacted into the upper fragment without splitting the latter, abnormal mobility may be absent, but the condition should be recognized by the shortening of the leg, and in some instances there will be sufficient angular deformity to indicate the nature of the lesion. The X-ray is of the greatest value in determining the nature of the injury in the exceptional cases in which the physical signs are indefinite.

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Treatment.—The desiderata in the treatment of these fractures are: reduction of deformity, immobilization of the fragments and restoration of function after the fragments have united. The details of treatment will vary with the type and severity of the fracture. In a simple transverse fracture of the upper end of the tibia, deformity is often slight and reduction easy. Strong traction on the leg with direct pressure over the displaced fragment will usually effect reduction. The fragments, however, are often so well apposed that nothing in the way of treatment is indicated aside from fixation. The lower extremity should be immo-

bilized on a long posterior splint extending from just above the heel to a point a short distance below the buttock. The regulation ham splint may be used or one may be made of plaster. The knee should be fixed in a position just short of complete extension and the padding employed should be so disposed as to evenly and firmly support the lower extremity throughout the length of the splint. If there is any tendency for the foot to be rotated inward or outward the splint should include the foot. This may be accomplished by a posterior plaster splint extending downward to include the heel and sole of the foot. The same result may be had by means of a long plaster stirrup extending well up onto the thigh, or the long side T-splint, similar to that used in fractures of the hip, may be employed. Whichever splint is used the means of securing it in position will be found in adhesive strips and bandages. In cases in which the traumatic reaction is severe, and rapid in onset, it may be advisable to postpone manipulation of the parts until it has subsided. This is particularly true when the fracture has entered the knee-joint with the development of a traumatic arthritis. When the fracture enters the joint cavity the correction of deformity and maintenance of the fragments in proper reduction is usually much more difficult than in simple transverse fracture. In a T-fracture, or breaking off of one of the tuberosities, an attempt should be made to force the fractured surfaces together so that the articular surfaces on the head of the tibia will be in proper relation with the condyles of the femur. This is often a difficult matter and requires skillful manipulation. If one of the tuberosities has been broken off, lateral deviation of the leg to the opposite side will often facilitate reduction of the displaced fragment. If the fracture is of the T-type with separation of the tuberosities, adduction or abduction of the leg will accomplish nothing. Under these circumstances strong traction in the axis of the tibia will be necessary while the tuberosities are forced together by lateral pressure. In some cases it will be impossible to approximate the tuberosities in this manner, and in other instances the tendency to recurrence of deformity may be so great that the tuberosities separate as soon as traction and lateral pressure are removed. Under these circumstances open reduction either with or without internal fixation is indicated. Not infrequently a loose fragment of bone between the tuberosities acts as an obstacle to reduction and will require removal before the fragments can be brought into proper position. In instances in which the shaft has been driven into the upper end of the tibia with extensive comminution, the destruction of bone may be so great that it is impossible to restore the original contour of the upper extremity of the bone. In this type of case continuous traction by means of Buck's extension will often accomplish more than any other method. When extension is employed for this purpose the lower extremity should be so fixed to the splint that the traction does not pull the axes of the tibia and fibula into the same straight line, otherwise the normal lateral angle of the knee will be obliterated.

What has been said of the treatment of fracture of the upper end of the tibia applies equally well in separation of the upper tibial epiphysis.

Avulsion of the tibial tubercle in the adult usually calls for operative treatment to secure the fragment in proper position. Straps of adhesive above the patella to prevent upward displacement, and bandages about the upper part of the leg to force the fragment home are, as a rule, only partially successful. If there has been little or no upward displacement of the fragment nonoperative measures will probably produce the desired result. Starting of the tubercle as an epiphysis is usually not attended by much displacement and the treatment will consist of fixation and rest until the loosened portion of the epiphysis has become firmly fixed again.

In luxations of the head of the fibula, pads may be so placed, and held in position by straps of adhesive plaster, as to prevent recurrence of deformity. The lower extremity should be immobilized for three or four weeks, and in backward luxations the condition should be treated with the knee semiflexed to relax the pull of the biceps. If these measures are not effective in maintaining reduction, or if evidences of nerve laceration are present, operation is indicated. Operation is also indicated in fractures of the fibular head with upward displacement of the fragment.

Operative Treatment.—In cases of simple transverse fracture of the tibia below the knee, with good reduction, operative intervention offers nothing, but when the fracture enters the joint cavity it may become necessary to cut down on the fragments to restore the articular surfaces of the knee-joint to their normal relations. Cases in which the tuberosities cannot otherwise be brought back into proper relation, or in which recurrence of deformity takes place, should be operated upon. If two longitudinal incisions are made, one on the inner and the other on the outer side of the joint, the fragments may be directly manipulated and reduction effected. If a solid engagement can be obtained between them, the incisions may be closed and splints applied. If a tendency toward the recurrence of deformity is manifest the fragments should be secured by some method of internal fixation. Non-absorbable materials should not be used if the fracture is compound. In a number of cases of T-fractures the author has found the following procedure satisfactory: two holes are drilled transversely through the tuberosities after they have been forced together, and a heavy silver wire is threaded through the holes and the ends tightly twisted together, thus maintaining the fragments in proper position and restoring the intra-articular surfaces in their normal relations. This method is equally efficient in instances in which one of the condyles is broken off and displaced. The principle is the same as that already described as "transverse wiring" under the heading of "Operative Treatment of the Lower End of the Femur." Nails, screws, and the Lane plate are at a discount in this region because of the internal structure of the upper end of the tibia which is composed of a loose cancellous tissue. Compound fractures of the upper end of the tibia should be treated according to the principles laid down under the heading of "The Treatment of Compound Fractures" on page 789.

Avulsion of the tibial tubercle with displacement of the fragment can seldom be reduced and maintained in proper position without operation. The fragment may be secured in place by means of a small nail or it may be sutured to the adjacent periosteum and surrounding soft tissues with absorbable suture material. Probably the best method in the adult, is to secure it to the shaft by means of a loop of silver wire. The scale of bone torn away may be too small to fix in this manner, or instead of an avulsion there may be a rupture of the patellar ligament, and when either of these conditions is encountered, the operation must consist of suturing of the soft tissues to properly anchor the ligament. When the tubercle is avulsed as an epiphysis it should not be sutured in position with anything except absorbable material.

An occasion calling for open reduction of a complete separation of the upper tibial epiphysis almost never arises. In fractures or dislocations of the upper end of the fibula, the condition most often rendering operation necessary, is injury to the peroneal nerve as it winds around the neck of the bone. When a portion of the fibular head has been displaced upward by the pull of the biceps, the fragment should be exposed, replaced and sutured in position. Non-operative methods of correcting this displacement are usually not successful.

In dislocations of the head of the fibula the most prompt recovery and complete restoration of function follow open reduction, with fixation of the head in proper position against the external tibial tuberosity. This may be accomplished by suturing the soft tissues about the head or by means of a single loop of wire passed through the adjacent portion of the tuberosity.

After-Treatment.—The first portion of the after-treatment will depend largely on the intensity of the traumatic reaction following the injury and whether or not the knee-joint is involved. When the reaction is severe it is often best to postpone manipulation of the parts until it has subsided. The lower extremity should be treated on a pillow-splint and the member elevated to favor circulation. The ice cap will aid materially in controlling the swelling. Undue constriction of the member should be avoided. With the subsidence of swelling, reduction should be accomplished by non-operative methods, if possible, or with operation if necessary. At the end of ten days or two weeks a permanent dressing should be applied. The plaster cast or plaster splints will be found quite satisfactory in this respect. If the plaster cast is used it should be split up the front before the plaster has set so that it may be removed during the after-treatment for inspection, massage and passive motion of the leg. Repeated adjustments will be found necessary during the after-treatment to keep the patient comfortable. Frequent inspection of the leg is necessary to recognize and treat pressure points on the skin, should they develop. In the healthy adult union is to be expected in an uncomplicated case at the end of six weeks, but the callus at this time is too soft to withstand any considerable strain. The full weight should not be borne on the leg for another month. Gratifying results have been obtained by use of the ambulatory pneumatic splint in simple fractures of this region. When this splint is employed it is often possible to begin the ambulatory treatment as soon as the acute swelling has subsided. In compound fractures of the upper end of the tibia recovery may be much delayed by the development of

necrotic bone or arthritis of the knee. Persistent discharging sinuses call for operation to remove the dead bone. Early guarded passive motion will accomplish a great deal in the prevention of permanent adhesions within the joint cavity. Anesthesia and forcible passive motion may be indicated to break up organized adhesions within the knee. Even arthrotomy may be called for in instances in which the adhesions are unusually strong. Early passive motion is called for to restore the function of the knee but the greatest care should be exercised to avoid refracture during the time the callus is friable. If a firm grasp be taken of the upper end of the tibia, force may be applied with much less risk than is the case when the leg is moved by the usual grip above the ankle. The lower the leg is grasped, in performing passive motion, the less the surgeon appreciates the leverage he is exerting against the upper end of the bone and the articulation. The dressing should be renewed from time to time to accommodate the changes which occur with the onset and subsidence of swelling. The older the patient the longer the time required for firm union to take place and the more imperfect recovery will be in the end.

In avulsion of the tubercle of the tibia union may be expected within six weeks and the member may be actively used at the end of two and a half months. If the condition has been treated by non-operative methods the parts should be frequently inspected to see that the strappings are properly performing their function in holding the fragment in reduction.

In separation of the upper tibial epiphysis the knee should be immobilized for a period of six weeks during the latter half of which time passive motion should be performed at intervals of four or five days.

In dislocations of the upper end of the fibula retentive apparatus should be kept in place for about a month, provided the luxation has not been secured in position by operation and internal fixation. During this time undue strain should be avoided, especially activities which involve forceful contraction of the flexors of the leg of which the biceps is one.

Prognosis.—The prognosis of fractures of the upper end of the tibia is very variable according to the extent and severity of the lesion. Simple fractures not produced by severe trauma are usually followed by complete restoration of function. On the other hand, a severe compound fracture entering the knee-joint may be

followed by infection of the knee-joint with septicemia and death. Restoration of function in severe cases is usually prolonged and seldom complete. The development of septic arthritis renders the fracture itself only of secondary importance. The prognosis following operative cases is better than those treated by non-operative methods. Union often takes place with permanent thickening below the knee and the motion in the articulation is not infrequently restricted.

The prognosis of avulsion of the tubercle of the tibia in the adult is good with proper treatment; when separated as an epiphysis the prognosis is equally good.

The prognosis of fractures and dislocations of the upper end of the fibula is good, aside from the injuries sustained by the peroneal nerve. When the nerve is injured the outlook varies with the degree of the injury and the completeness of repair which is possible at operation.

CHAPTER XLV.

FRACTURES OF THE SHAFTS OF THE BONES OF THE LEG.

The division of fractures of the leg into: Fractures of the upper ends, Fractures of the shafts and Fractures of the lower ends, is not a scientific classification of these injuries, yet it forms a working basis for their consideration. There is no hard and fast line to be drawn between fractures of the shaft and fractures of the extremities. The nearer the break is located to the end of the bone the more it assumes the characteristics of a typical fracture of the extremity.

Surgical Anatomy.—The shafts of the bones of the leg are each ossified from centers which make their appearances during the seventh and eighth weeks of fœtal life. That for the tibial shaft delevops first. The shaft of the tibia constitutes the main strength of the leg. It is distinctly triangular in cross-section and shows three surfaces separated from each other by three prominent borders. The anterior border is subcutaneous and may be palpated from the tibial tubercle to the internal malleolus. The lower third of this border, however, is much less prominent, and is more or less obscured by the tendon of the tibialis anticus. The external border is directed toward the fibula and has attached to it the heavy interosseous membrane. The internal border may be palpated throughout, though in well developed persons the middle portion is more or less encroached upon by the bellies of the flexor muscles of the foot. The internal surface of the bone is subcutaneous except for the insertions of the gracilis, semitendonosus and sartorius, which are attached to the upper end, a short distance below the inner tuberosity. With the intense swelling, which so frequently develops following fracture, it is hard to realize that this portion of the bone is subcutaneous. The thickening is often sufficient to obscure the outline and render palpation difficult, but it should be remembered that this infiltration is in the subcutaneous tissues and that gentle, firm and continued pressure, with the finger tips,

will so displace these fluids that the condition of the bone may be recognized.

The weakest part of the tibial shaft is at, and just below, the junction of the middle and lower thirds, and it is here that fracture most frequently occurs. The shaft is composed of a tube of heavy compact tissue and the fractures occurring in this region are clean cut and show no impaction or crushing of bone tissue. Comminution is not infrequently seen and the fracture may be multiple; but the fragments are hard and the edges clean cut, and screws find a firm foothold when the Lane plate is employed to secure reduction and immobilization. The shaft of the tibia normally bows slightly forward while the fibula bows a little in the opposite direction.

The shaft of the fibula is almost entirely surrounded by muscles which act as cushions in the presence of direct violence. The upper extremity and external malleolus are the only portions of the fibula which can be satisfactorily palpated. The lower third or fourth of the external surface of the bone may be felt between the peroneus tertius anteriorly and the peroneus longus and brevis posteriorly. The shaft of the fibula is long and slender and normally possesses a certain degree of spring when compressed against the tibia. This fact is of importance clinically since lateral pressure, in the presence of fracture, will detect an increase or loss of this spring as compared with the opposite fibula, even though the bone cannot be directly palpated.

The shafts of the bones of the leg are usually both broken, though isolated fracture of either bone may occur. The fibula is more frequently fractured than the tibia. When both bones are broken the lesion in the fibula is usually at the higher level. The fracture in the tibia may be transverse, oblique, spiral, or longitudinal. Spiral and oblique fractures are quite common below the middle of the shaft and are usually the result of indirect violence. Transverse fractures are more common above the middle of the shaft and are usually due to direct violence.

The upper posterior portions of the shafts of the bones of the leg are covered and protected by the heavy calf muscles, and the tendo Achillis in the lower part of the leg is capable of breaking the force of a blow, when direct violence is sustained from behind. Anteriorly the tibia has no such protection but receives the full force of direct violence applied to the shin.

CHAPTER XLIV.

INJURIES JUST BELOW THE KNEE—FRACTURES OF THE TIBIA AND FIBULA (UPPER ENDS).

The injuries occurring in this region of the leg and to be considered under this heading are: fracture of the upper end of the tibia (either into or below the knee-joint), separation of the upper tibial epiphysis, fracture of the upper end of the fibula, separation of the upper tibial epiphysis and dislocations of the upper tibiofibular articulation.

Surgical Anatomy.—The broad, expanded, upper extremity of the tibia which forms the tuberosities, is largely subcutaneous and can be readily palpated just below the plane of the knee-joint. The inner tuberosity presents a horizontal groove on its posterior aspect for the insertion of a portion of the semimembranosus. The circumference of the tuberosity is taken up by the attachment of the capsule and the internal lateral ligament. In like manner the circumference of the outer tuberosity is taken up by the capsule on the outer side of the joint, but the external lateral ligaments of the knee are not attached to this bone but to the head of the fibula. The posterior aspect of the outer tuberosity articulates with the upper end of the fibula, and half-way between the tibial tubercle and the fibular head is inserted the lower end of the ilio-tibial band. The upper end of the tibia is composed of cancellous tissue which is encased in a thin layer of compact bone. The heavy compact tissue of the shaft grows rapidly thinner as the upper end of the bone is approached.

Fracture of the upper end of the tibia is the result of direct or indirect violence, usually the former. The line of fracture may be vertical, entering the joint cavity, or it may be transverse and below the articulation. Transverse fracture of the upper end of the tibia is usually the result of direct violence and the displacement is, as a rule, not great. The superficial position of the bone accounts for the frequency of compound fractures in this region, especially when produced by direct violence. When the fracture

The subcutaneous position of the anterior border and internal surface of the tibia accounts for the large proportion of compound fractures in this region, especially when caused by direct violence. The direction of the oblique or spiral fracture is usually from above, downward and forward.

Etiology.—Fracture of the shafts of the bones of the leg is rather a common accident and results from either direct or indirect violence. It is often caused by a twist of the leg, a fall from a height, a direct blow on the shin, or a crushing force, such as being run over by a wagon. Fractures of the fibula alone are usually the result of direct violence. Fracture of the tibia alone is almost always the result of direct violence. Fracture of the shafts of these bones occurs most frequently during the fourth, fifth and sixth decades. This accident is the most frequent, occurring in the

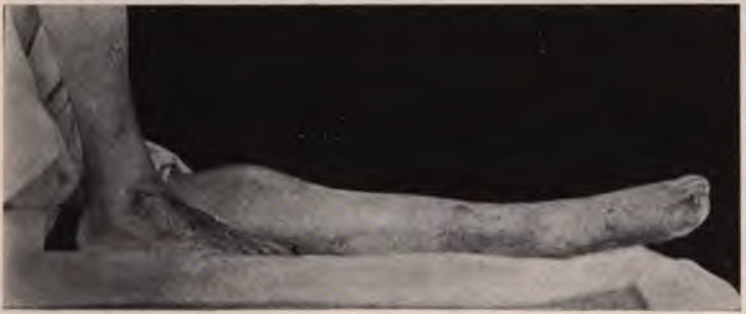

Fig. 686.

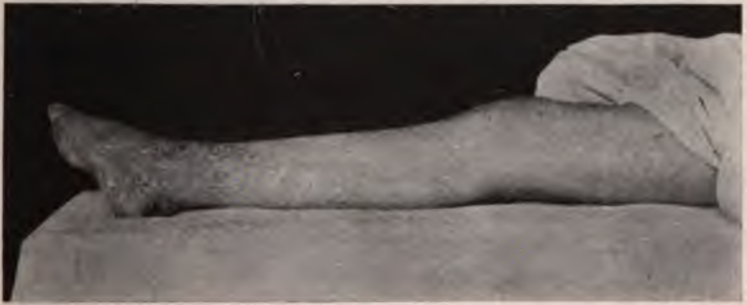

Fig. 687.

Figs. 686 and 687.—Show a simple fracture of both bones of the leg in their lower thirds. Note the inward falling of the foot, while the position of the knee is normal. Photographs taken a few minutes following injury.

necrotic bone or arthritis of the knee. Persistent discharging sinuses call for operation to remove the dead bone. Early guarded passive motion will accomplish a great deal in the prevention of permanent adhesions within the joint cavity. Anesthesia and forcible passive motion may be indicated to break up organized adhesions within the knee. Even arthrotomy may be called for in instances in which the adhesions are unusually strong. Early passive motion is called for to restore the function of the knee but the greatest care should be exercised to avoid refracture during the time the callus is friable. If a firm grasp be taken of the upper end of the tibia, force may be applied with much less risk than is the case when the leg is moved by the usual grip above the ankle. The lower the leg is grasped, in performing passive motion, the less the surgeon appreciates the leverage he is exerting against the upper end of the bone and the articulation. The dressing should be renewed from time to time to accommodate the changes which occur with the onset and subsidence of swelling. The older the patient the longer the time required for firm union to take place and the more imperfect recovery will be in the end.

In avulsion of the tubercle of the tibia union may be expected within six weeks and the member may be actively used at the end of two and a half months. If the condition has been treated by non-operative methods the parts should be frequently inspected to see that the strappings are properly performing their function in holding the fragment in reduction.

In separation of the upper tibial epiphysis the knee should be immobilized for a period of six weeks during the latter half of which time passive motion should be performed at intervals of four or five days.

In dislocations of the upper end of the fibula retentive apparatus should be kept in place for about a month, provided the luxation has not been secured in position by operation and internal fixation. During this time undue strain should be avoided, especially activities which involve forceful contraction of the flexors of the leg of which the biceps is one.

Prognosis.—The prognosis of fractures of the upper end of the tibia is very variable according to the extent and severity of the lesion. Simple fractures not produced by severe trauma are usually followed by complete restoration of function. On the other hand, a severe compound fracture entering the knee-joint may be

followed by infection of the knee-joint with septicemia and death. Restoration of function in severe cases is usually prolonged and seldom complete. The development of septic arthritis renders the fracture itself only of secondary importance. The prognosis following operative cases is better than those treated by non-operative methods. Union often takes place with permanent thickening below the knee and the motion in the articulation is not infrequently restricted.

The prognosis of avulsion of the tubercle of the tibia in the adult is good with proper treatment; when separated as an epiphysis the prognosis is equally good.

The prognosis of fractures and dislocations of the upper end of the fibula is good, aside from the injuries sustained by the peroneal nerve. When the nerve is injured the outlook varies with the degree of the injury and the completeness of repair which is possible at operation.

tion of the knee-joint, though the two external lateral ligaments of the knee are attached to it. The long head of the biceps (outer hamstring muscle) is inserted around the base of the styloid process, and the attachments of the soleus, peroneus longus and extensor longus digitorum are continued upward from the shaft onto the upper extremity of the bone. This epiphysis of the fibula begins to ossify about the fourth year and joins the shaft at about the twenty-fifth. Violent contraction of the biceps is known to have caused fracture of the upper end of the fibula, or separation of the epiphysis, and adduction of the leg has produced the same result through the pull of the external lateral ligaments. Fracture of the upper end of the fibula just below the head of the bone is usually the result of direct violence. Occasionally it accompanies fracture of the upper end of the tibia.

The upper tibio-fibular articulation is a simple arthrodial joint with very limited motion. The articular surfaces entering into its formation are flat and the integrity of the joint depends entirely on the strength of the ligaments holding the two bones together. This joint possesses an anterior and a posterior ligament which are thickenings in the capsule surrounding the articulation. Anterior and posterior displacements are prevented as long as the force is not sufficient to rupture these ligaments. Upward displacement is prevented not only by these ligaments but by the interosseous membrane and the lower tibio-fibular articulation. The importance of displacements of the upper end of the fibula depends mainly on the fact that the peroneal nerve winds around the neck of the bone and may be injured with direct violence to the outer side of the leg, or when the head of the fibula is luxated. This nerve can be felt beneath the skin behind the tendon of the biceps. It passes between the tendon of the biceps and the outer head of the gastrocnemius and then winds around the neck of the fibula. It passes forward to join the anterior tibial artery and gives off branches, as it passes down the front of the leg, to supply the extensors of the foot. Injury to this nerve is accompanied by foot drop.

Etiology. Fractures of the upper ends of the tibia and fibula are usually due to direct violence. Forcible adduction or abduction of the leg may result in fracture of the tuberosities. Violence transmitted in the axis of the leg may produce fracture of the upper end of the tibia and fibula, although all forms of indirect

will so displace these fluids that the condition of the bone may be recognized.

The weakest part of the tibial shaft is at, and just below, the junction of the middle and lower thirds, and it is here that fracture most frequently occurs. The shaft is composed of a tube of heavy compact tissue and the fractures occurring in this region are clean cut and show no impaction or crushing of bone tissue. Comminution is not infrequently seen and the fracture may be multiple; but the fragments are hard and the edges clean cut, and screws find a firm foothold when the Lane plate is employed to secure reduction and immobilization. The shaft of the tibia normally bows slightly forward while the fibula bows a little in the opposite direction.

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The upper posterior portions of the shafts of the bones of the leg are covered and protected by the heavy calf muscles, and the tendo Achillis in the lower part of the leg is capable of breaking the force of a blow, when direct violence is sustained from behind. Anteriorly the tibia has no such protection but receives the full force of direct violence applied to the shin.

violence, is often compound and if the line of fracture enters the joint it may be followed by suppurative arthritis.

Avulsion of the tubercle of the tibia is accompanied by a more or less upward displacement of the patella according to the extent of tearing in the lateral expansions of the aponeurosis of the quadriceps extensor. The loose detached fragment can be palpated without difficulty unless the swelling is intense. The ligamentum patellæ is abnormally lax. Rupture of the patellar ligament gives a similar symptom-complex except for the absence of the detached fragment of the tubercle.

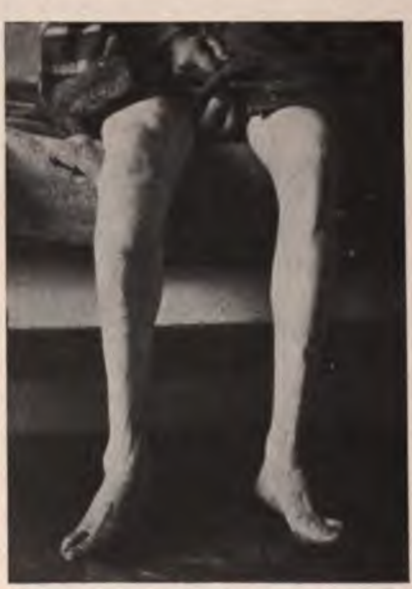

Fig. 682.—Longitudinal fracture of the upper end of the right tibia. Tuberosities spread so that finger may be pressed into external articular cavity just above prominence indicated by arrow. Such a fracture will interfere with the use of the knee-joint unless the fragments are brought together and held in place. Operation is usually necessary in this type of case to secure the best results.

Separation of the upper tibial epiphysis is attended by symptoms similar to fracture in this region. The epiphysis may be displaced in any direction. The crepitus produced by manipulation is soft and cartilaginous. The condition is extremely rare.

Fracture or epiphyseal separation of the upper end of the fibula is accompanied by local tenderness and pain especially when the leg is used. It is often possible to move the head of the bone about. Crepitus is usually elicited without difficulty. If the fracture is

through the tibio-fibular articulation or below it, pressure on the shaft of the bone, in the middle of the leg, will produce pain at the seat of fracture. Injury to the peroneal nerve will be productive of characteristic symptoms in motion and sensation throughout the distribution of the nerve. In luxations of the fibular head the upper end of the bone is more prominent than normal and its displacement either forward or backward is, as a rule, easily recognized.

Injuries to vessels and nerves are not as common in this region of the leg as they are in fractures of the lower end of the femur but when they do occur the same train of symptoms will become manifest.

Diagnosis.—There is, as a rule, little difficulty in recognizing fracture in this region. A simple transverse break, however, just below the tibial tuberosities, may, in rare instances, be difficult to determine without the aid of the X-ray. In the exceptional cases in which the shaft is impacted into the upper fragment without splitting the latter, abnormal mobility may be absent, but the condition should be recognized by the shortening of the leg, and in some instances there will be sufficient angular deformity to indicate the nature of the lesion. The X-ray is of the greatest value in determining the nature of the injury in the exceptional cases in which the physical signs are indefinite.

When the upper end of the fibula alone is fractured the patient may be able to get about, though the use of the member entails more or less swelling and pain. This fracture has not infrequently been overlooked in spite of the fact that pressure in the middle of the shaft is productive of pain at the site of the lesion, if the fracture is below or through the upper tibio-fibular articulation. If the fracture is above this level it should be recognized by direct palpation.

Treatment.—The desiderata in the treatment of these fractures are: reduction of deformity, immobilization of the fragments and restoration of function after the fragments have united. The details of treatment will vary with the type and severity of the fracture. In a simple transverse fracture of the upper end of the tibia, deformity is often slight and reduction easy. Strong traction on the leg with direct pressure over the displaced fragment will usually effect reduction. The fragments, however, are often so well apposed that nothing in the way of treatment is indicated aside from fixation. The lower extremity should be immo-

bilized on a long posterior splint extending from just above the heel to a point a short distance below the buttock. The regulation ham splint may be used or one may be made of plaster. The knee should be fixed in a position just short of complete extension and the padding employed should be so disposed as to evenly and firmly support the lower extremity throughout the length of the splint. If there is any tendency for the foot to be rotated inward or outward the splint should include the foot. This may be accomplished by a posterior plaster splint extending downward to include the heel and sole of the foot. The same result may be had by means of a long plaster stirrup extending well up onto the thigh, or the long side T-splint, similar to that used in fractures of the hip, may be employed. Whichever splint is used the means of securing it in position will be found in adhesive strips and bandages. In cases in which the traumatic reaction is severe, and rapid in onset, it may be advisable to postpone manipulation of the parts until it has subsided. This is particularly true when the fracture has entered the knee-joint with the development of a traumatic arthritis. When the fracture enters the joint cavity the correction of deformity and maintenance of the fragments in proper reduction is usually much more difficult than in simple transverse fracture. In a T-fracture, or breaking off of one of the tuberosities, an attempt should be made to force the fractured surfaces together so that the articular surfaces on the head of the tibia will be in proper relation with the condyles of the femur. This is often a difficult matter and requires skillful manipulation. If one of the tuberosities has been broken off, lateral deviation of the leg to the opposite side will often facilitate reduction of the displaced fragment. If the fracture is of the T-type with separation of the tuberosities, adduction or abduction of the leg will accomplish nothing. Under these circumstances strong traction in the axis of the tibia will be necessary while the tuberosities are forced together by lateral pressure. In some cases it will be impossible to approximate the tuberosities in this manner, and in other instances the tendency to recurrence of deformity may be so great that the tuberosities separate as soon as traction and lateral pressure are removed. Under these circumstances open reduction either with or without internal fixation is indicated. Not infrequently a loose fragment of bone between the tuberosities acts as an obstacle to reduction and will require removal before the fragments can be brought into proper position. In instances in which the shaft has been driven into the upper end of the tibia with extensive comminution, the destruction of bone may be so great that it is impossible to restore the original contour of the upper extremity of the bone. In this type of case continuous traction by means of Buck's extension will often accomplish more than any other method. When extension is employed for this purpose the lower extremity should be so fixed to the splint that the traction does not pull the axes of the tibia and fibula into the same straight line, otherwise the normal lateral angle of the knee will be obliterated.

What has been said of the treatment of fracture of the upper end of the tibia applies equally well in separation of the upper tibial epiphysis.

Avulsion of the tibial tubercle in the adult usually calls for operative treatment to secure the fragment in proper position. Straps of adhesive above the patella to prevent upward displacement, and bandages about the upper part of the leg to force the fragment home are, as a rule, only partially successful. If there has been little or no upward displacement of the fragment non-operative measures will probably produce the desired result. Starting of the tubercle as an epiphysis is usually not attended by much displacement and the treatment will consist of fixation and rest until the loosened portion of the epiphysis has become firmly fixed again.

In luxations of the head of the fibula, pads may be so placed, and held in position by straps of adhesive plaster, as to prevent recurrence of deformity. The lower extremity should be immobilized for three or four weeks, and in backward luxations the condition should be treated with the knee semiflexed to relax the pull of the biceps. If these measures are not effective in maintaining reduction, or if evidences of nerve laceration are present, operation is indicated. Operation is also indicated in fractures of the fibular head with upward displacement of the fragment.

Operative Treatment.—In cases of simple transverse fracture of the tibia below the knee, with good reduction, operative intervention offers nothing, but when the fracture enters the joint cavity it may become necessary to cut down on the fragments to restore the articular surfaces of the knee-joint to their normal relations. Cases in which the tuberosities cannot otherwise be brought back into proper relation, or in which recurrence of deformity takes place, should be operated upon. If two longitudinal incisions are made, one on the inner and the other on the outer side of the joint, the fragments may be directly manipulated and reduction effected. If a solid engagement can be obtained between them, the incisions may be closed and splints applied. If a tendency toward the recurrence of deformity is manifest the fragments should be secured by some method of internal fixation. Non-absorbable materials should not be used if the fracture is compound. In a number of cases of T-fractures the author has found the following procedure satisfactory: two holes are drilled transversely through the tuberosities after they have been forced together, and a heavy silver wire is threaded through the holes and the ends tightly twisted together, thus maintaining the fragments in proper position and restoring the intra-articular surfaces in their normal relations. This method is equally efficient in instances in which one of the condyles is broken off and displaced. The principle is the same as that already described as "transverse wiring" under the heading of "Operative Treatment of the Lower End of the Femur." Nails, screws, and the Lane plate are at a discount in this region because of the internal structure of the upper end of the tibia which is composed of a loose cancellous tissue. Compound fractures of the upper end of the tibia should be treated according to the principles laid down under the heading of "The Treatment of Compound Fractures" on page 789.

Avulsion of the tibial tubercle with displacement of the fragment can seldom be reduced and maintained in proper position without operation. The fragment may be secured in place by means of a small nail or it may be sutured to the adjacent periosteum and surrounding soft tissues with absorbable suture material. Probably the best method in the adult, is to secure it to the shaft by means of a loop of silver wire. The scale of bone torn away may be too small to fix in this manner, or instead of an avulsion there may be a rupture of the patellar ligament, and when either of these conditions is encountered, the operation must consist of suturing of the soft tissues to properly anchor the ligament. When the tubercle is avulsed as an epiphysis it should not be sutured in position with anything except absorbable material.

An occasion calling for open reduction of a complete separation of the upper tibial epiphysis almost never arises. In fractures or dislocations of the upper end of the fibula, the condition most often rendering operation necessary, is injury to the peroneal nerve as it winds around the neck of the bone. When a portion of the fibular head has been displaced upward by the pull of the biceps, the fragment should be exposed, replaced and sutured in position. Non-operative methods of correcting this displacement are usually not successful.

In dislocations of the head of the fibula the most prompt recovery and complete restoration of function follow open reduction, with fixation of the head in proper position against the external tibial tuberosity. This may be accomplished by suturing the soft tissues about the head or by means of a single loop of wire passed through the adjacent portion of the tuberosity.

After-Treatment.—The first portion of the after-treatment will depend largely on the intensity of the traumatic reaction following the injury and whether or not the knee-joint is involved. When the reaction is severe it is often best to postpone manipulation of the parts until it has subsided. The lower extremity should be treated on a pillow-splint and the member elevated to favor circulation. The ice cap will aid materially in controlling the swelling. Undue constriction of the member should be avoided. With the subsidence of swelling, reduction should be accomplished by non-operative methods, if possible, or with operation if necessary. At the end of ten days or two weeks a permanent dressing should be applied. The plaster cast or plaster splints will be found quite satisfactory in this respect. If the plaster cast is used it should be split up the front before the plaster has set so that it may be removed during the after-treatment for inspection, massage and passive motion of the leg. Repeated adjustments will be found necessary during the after-treatment to keep the patient comfortable. Frequent inspection of the leg is necessary to recognize and treat pressure points on the skin, should they develop. In the healthy adult union is to be expected in an uncomplicated case at the end of six weeks, but the callus at this time is too soft to withstand any considerable strain. The full weight should not be borne on the leg for another month. Gratifying results have been obtained by use of the ambulatory pneumatic splint in simple fractures of this region. When this splint is employed it is often possible to begin the ambulatory treatment as soon as the acute swelling has subsided. In compound fractures of the upper end of the tibia recovery may be much delayed by the development of

necrotic bone or arthritis of the knee. Persistent discharging sinuses call for operation to remove the dead bone. Early guarded passive motion will accomplish a great deal in the prevention of permanent adhesions within the joint cavity. Anesthesia and forcible passive motion may be indicated to break up organized adhesions within the knee. Even arthrotomy may be called for in instances in which the adhesions are unusually strong. Early passive motion is called for to restore the function of the knee but the greatest care should be exercised to avoid refracture during the time the callus is friable. If a firm grasp be taken of the upper end of the tibia, force may be applied with much less risk than is the case when the leg is moved by the usual grip above the ankle. The lower the leg is grasped, in performing passive motion, the less the surgeon appreciates the leverage he is exerting against the upper end of the bone and the articulation. The dressing should be renewed from time to time to accommodate the changes which occur with the onset and subsidence of swelling. The older the patient the longer the time required for firm union to take place and the more imperfect recovery will be in the end.

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In separation of the upper tibial epiphysis the knee should be immobilized for a period of six weeks during the latter half of which time passive motion should be performed at intervals of four or five days.

In dislocations of the upper end of the fibula retentive apparatus should be kept in place for about a month, provided the luxation has not been secured in position by operation and internal fixation. During this time undue strain should be avoided, especially activities which involve forceful contraction of the flexors of the leg of which the biceps is one.

Prognosis.—The prognosis of fractures of the upper end of the tibia is very variable according to the extent and severity of the lesion. Simple fractures not produced by severe trauma are usually followed by complete restoration of function. On the other hand, a severe compound fracture entering the knee-joint may be

followed by infection of the knee-joint with septicemia and death. Restoration of function in severe cases is usually prolonged and seldom complete. The development of septic arthritis renders the fracture itself only of secondary importance. The prognosis following operative cases is better than those treated by non-operative methods. Union often takes place with permanent thickening below the knee and the motion in the articulation is not infrequently restricted.

The prognosis of avulsion of the tubercle of the tibia in the adult is good with proper treatment; when separated as an epiphysis the prognosis is equally good.

The prognosis of fractures and dislocations of the upper end of the fibula is good, aside from the injuries sustained by the peroneal nerve. When the nerve is injured the outlook varies with the degree of the injury and the completeness of repair which is possible at operation.

CHAPTER XLV.

FRACTURES OF THE SHAFTS OF THE BONES OF THE LEG.

The division of fractures of the leg into: Fractures of the upper ends, Fractures of the shafts and Fractures of the lower ends, is not a scientific classification of these injuries, yet it forms a working basis for their consideration. There is no hard and fast line to be drawn between fractures of the shaft and fractures of the extremities. The nearer the break is located to the end of the bone the more it assumes the characteristics of a typical fracture of the extremity.

Surgical Anatomy.—The shafts of the bones of the leg are each ossified from centers which make their appearances during the seventh and eighth weeks of fœtal life. That for the tibial shaft delevops first. The shaft of the tibia constitutes the main strength of the leg. It is distinctly triangular in cross-section and shows three surfaces separated from each other by three prominent borders. The anterior border is subcutaneous and may be palpated from the tibial tubercle to the internal malleolus. The lower third of this border, however, is much less prominent, and is more or less obscured by the tendon of the tibialis anticus. The external border is directed toward the fibula and has attached to it the heavy interosseous membrane. The internal border may be palpated throughout, though in well developed persons the middle portion is more or less encroached upon by the bellies of the flexor muscles of the foot. The internal surface of the bone is subcutaneous except for the insertions of the gracilis, semitendonosus and sartorius, which are attached to the upper end, a short distance below the inner tuberosity. With the intense swelling, which so frequently develops following fracture, it is hard to realize that this portion of the bone is subcutaneous. The thickening is often sufficient to obscure the outline and render palpation difficult, but it should be remembered that this infiltration is in the subcutaneous tissues and that gentle, firm and continued pressure, with the finger tips,

will so displace these fluids that the condition of the bone may be recognized.

The weakest part of the tibial shaft is at, and just below, the junction of the middle and lower thirds, and it is here that fracture most frequently occurs. The shaft is composed of a tube of heavy compact tissue and the fractures occurring in this region are clean cut and show no impaction or crushing of bone tissue. Comminution is not infrequently seen and the fracture may be multiple; but the fragments are hard and the edges clean cut, and screws find a firm foothold when the Lane plate is employed to secure reduction and immobilization. The shaft of the tibia normally bows slightly forward while the fibula bows a little in the opposite direction.

The shaft of the fibula is almost entirely surrounded by muscles which act as cushions in the presence of direct violence. The upper extremity and external malleolus are the only portions of the fibula which can be satisfactorily palpated. The lower third or fourth of the external surface of the bone may be felt between the peroneus tertius anteriorly and the peroneus longus and brevis posteriorly. The shaft of the fibula is long and slender and normally possesses a certain degree of spring when compressed against the tibia. This fact is of importance clinically since lateral pressure, in the presence of fracture, will detect an increase or loss of this spring as compared with the opposite fibula, even though the bone cannot be directly palpated.

The shafts of the bones of the leg are usually both broken, though isolated fracture of either bone may occur. The fibula is more frequently fractured than the tibia. When both bones are broken the lesion in the fibula is usually at the higher level. The fracture in the tibia may be transverse, oblique, spiral, or longitudinal. Spiral and oblique fractures are quite common below the middle of the shaft and are usually the result of indirect violence. Transverse fractures are more common above the middle of the shaft and are usually due to direct violence.

The upper posterior portions of the shafts of the bones of the leg are covered and protected by the heavy calf muscles, and the tendo Achillis in the lower part of the leg is capable of breaking the force of a blow, when direct violence is sustained from behind. Anteriorly the tibia has no such protection but receives the full force of direct violence applied to the shin.

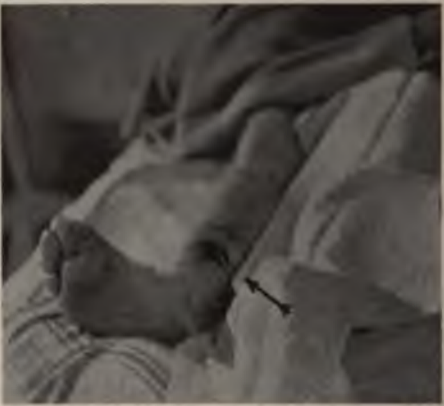


Fig. 683.—Compound fracture of both bones of the leg. Note the eversion of the foot and compare it with the patella which is directed upward.

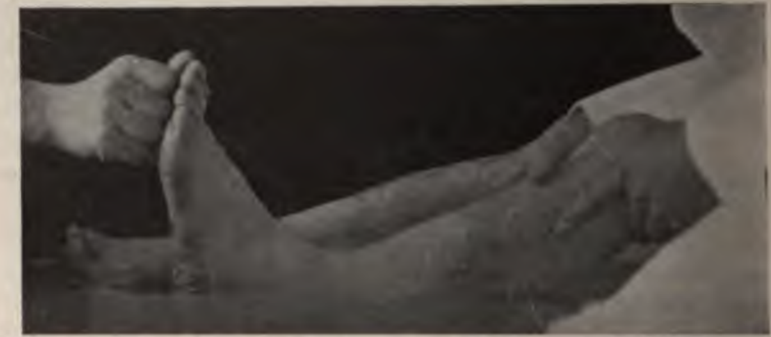


Fig. 684.—Fracture of both bones of the leg in their lower thirds. Note the flail-like condition.

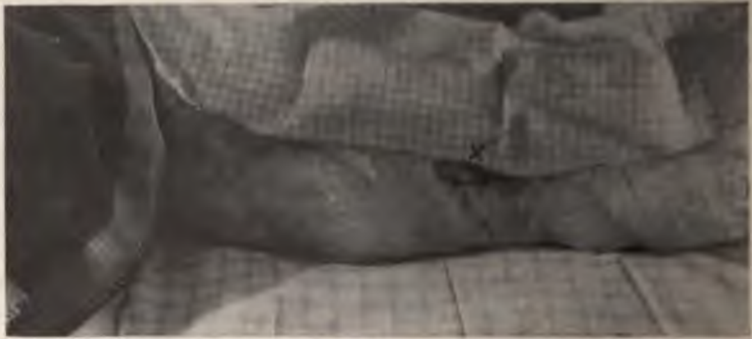


Fig. 685.—Compound fracture of both bones of the leg with shortening and eversion. Result of direct violence. Note the position of the patella which looks directly upward while the foot is decidedly everted. Lower end of upper fragment penetrated the skin where the wound is seen at "x."

The subcutaneous position of the anterior border and internal surface of the tibia accounts for the large proportion of compound fractures in this region, especially when caused by direct violence. The direction of the oblique or spiral fracture is usually from above, downward and forward.

Etiology.—Fracture of the shafts of the bones of the leg is rather a common accident and results from either direct or indirect violence. It is often caused by a twist of the leg, a fall from a height, a direct blow on the shin, or a crushing force, such as being run over by a wagon. Fractures of the fibula alone are usually the result of direct violence. Fracture of the tibia alone is almost always the result of direct violence. Fracture of the shafts of these bones occurs most frequently during the fourth, fifth and sixth decades. This accident is the most frequent, occurring in the

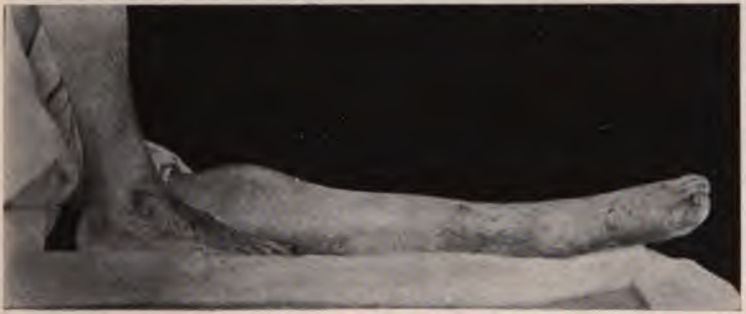


Fig. 686.

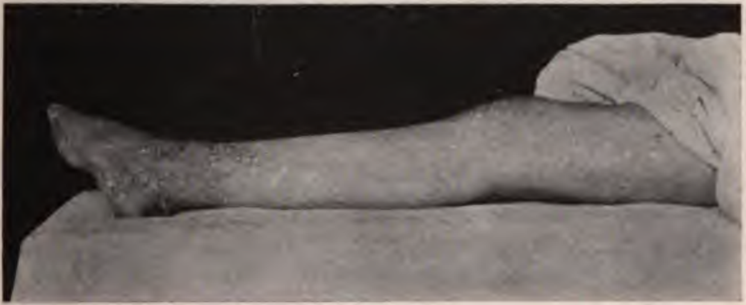


Fig. 687.

Figs. 686 and 687.—Show a simple fracture of both bones of the leg in their lower thirds. Note the inward falling of the foot, while the position of the knee is normal. Photographs taken a few minutes following injury.

lower extremity, and constitutes approximately six percent of all fractures.

Symptoms.—Immediate and total loss of function is the rule.

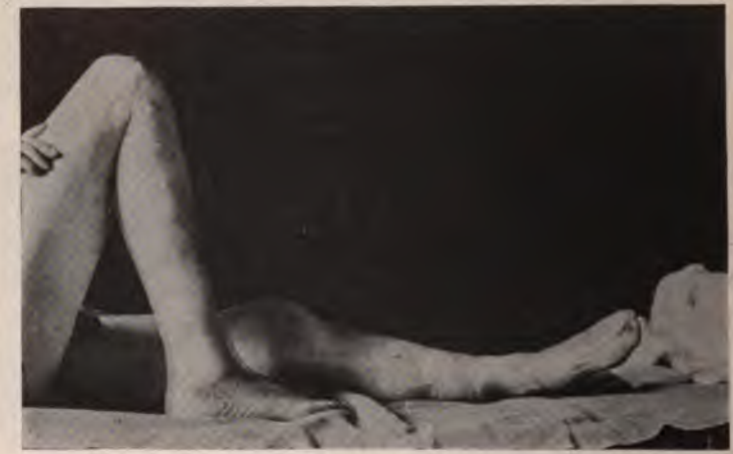


Fig. 688.

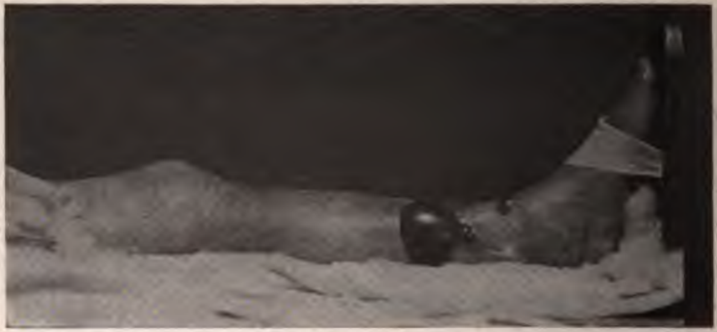


Fig. 689.

Figs. 688 and 689.—Fracture of both bones of the leg near junction of lower and middle thirds, seen a few minutes after the accident and again four days later. Note the position of the patella looking directly upward while the foot has fallen inward of its own weight. Condition flail-like. In Fig. 689 (same leg four days later) the deformity has been corrected and the sides of the fracture box, in which the leg has been placed, have been let down for inspection of the parts and readjustment of the padding. Note the swelling of the leg and the development of blood-blebs over the site of fracture. The leg is the most common site for the development of these blood-blebs following fracture. The leg should not be put in a permanent dressing until the denuded surfaces resulting from these blebs have thoroughly healed.

Pain, crepitus, abnormal mobility and deformity are almost uniformly present. The deformity is usually sufficient for the surgeon to recognize the condition by inspection alone. Fracture at the usual site (near the junction of the lower and middle thirds) commonly shows a downward and forward displacement of the lower end of the upper fragment with a corresponding upward and backward displacement of the lower fragment. The leg is usually flail-like and the foot falls either inward or outward (usually the latter), according to the position in which the lower extremity happens to be placed. When both bones are broken, abnormal mobility is much greater than when the tibia alone is fractured. It is not uncommon to see the end of either the upper or lower tibial fragment projecting through the skin on the anterior aspect of the leg.

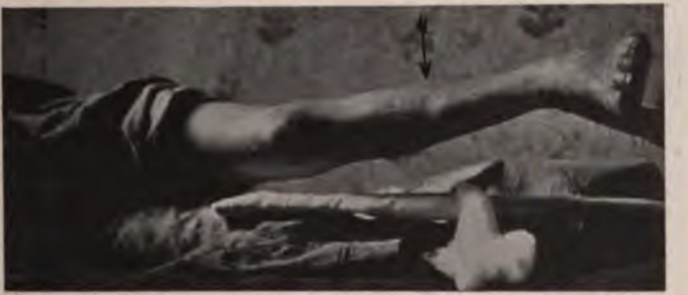


Fig. 690.—Green-stick fracture of the tibia in a child a few minutes following the injury. Note the slight inward bowing of the skin. In this case it was possible to slightly spring the tibia inward by lateral pressure. Arrow indicates site of fracture.

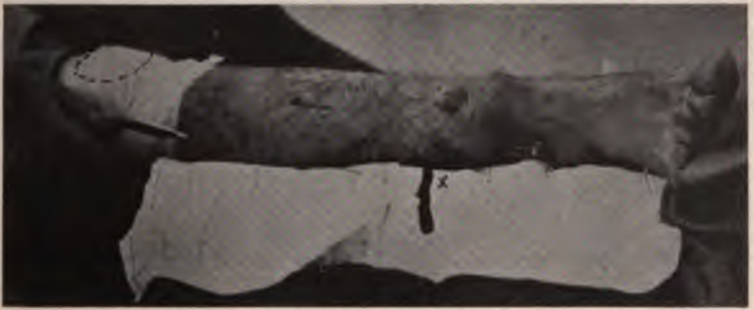


Fig. 691.—Double compound fracture of both bones of the leg. Note the position of the patella, as outlined through the bandages, and the relation it bears to the foot which is everted and displaced posteriorly. Leg below the fracture is flail-like permitting of displacement in any direction. Extensive injury to soft tissues. The tibia and fibula (upper fragments) penetrated the skin through the wound on the outer side of the leg as indicated by "X" in plate. The blood on the towel is coming from this wound. Injury produced by heavy wagon loaded with three tons of coal passing over leg.

Fracture of the fibula alone is not attended by much loss of function unless the break is close to the ankle, and even then the author has seen cases in which the patient was able to walk, in spite of the injury. Pain occurs with use of the limb and pressure on the shaft of the bone will produce pain at the site of the lesion even though the pressure be made above or below the level of fracture. Fracture of the fibula near the ankle may disturb the mortice of the ankle joint by an outward displacement of the external malleolus as the upper end of the lower fragment is displaced toward the tibia.

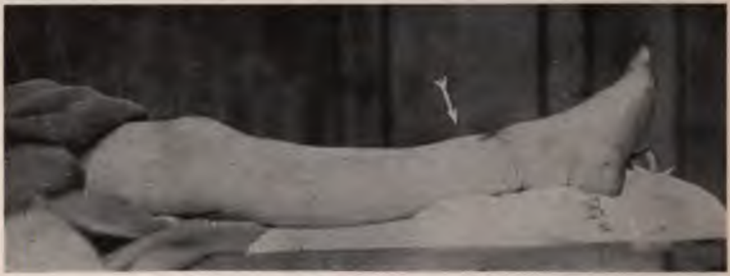


Fig. 692.

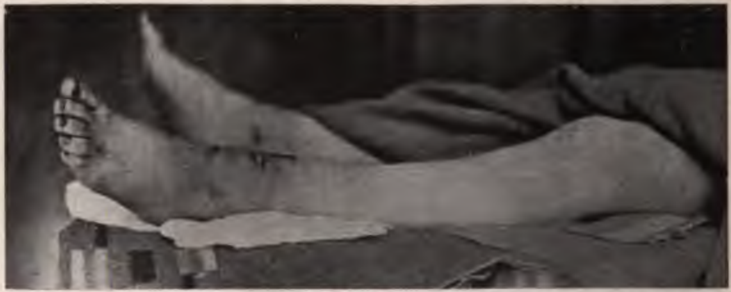


Fig. 693.

Figs. 692 and 693.—Two views of an oblique fracture of the tibia a few inches above the ankle. The displacement is very slight between the tibial fragments. The line of the fracture can be recognized only by careful palpation. This almost complete absence of deformity is due to the fact that the fibula remains intact and acts as a splint for the broken tibia. Photograph about twelve hours following the accident. Arrow indicates position of fracture.

Fracture of the bones of the leg is usually attended by severe traumatic reaction within a few hours of the accident. Swelling is pronounced and ecchymosis develops in the region of the fracture during the first twenty-four to forty-eight hours. It is not uncommon for blebs to form in the skin at any time during the first week and their contents may be either blood or serum or a mixture of these two materials (see Fig. 689). In fractures of this type the injury to the soft tissues may be so great that the fracture itself is only of secondary importance. If the fibula remains intact abnormal mobility will usually not be as pronounced as when both bones are broken. Green-stick fracture of the tibia sometimes occurs in children and may be accompanied by such slight preternatural mobility as to render recognition difficult (see Fig. 690). Most fractures of the leg are accompanied by severe traumatic reaction but occasionally a case is seen in which the causative trauma has been just sufficient to produce the fracture and the resultant swelling and inflammation are slight. In fractures produced by great trauma the skin covering the tibia may be extensively torn and loose fragments of bone may be seen lying in the wound. In rare instances the circulation below the fracture may be destroyed so that no pulse can be detected in the dorsalis pedis, the foot be-

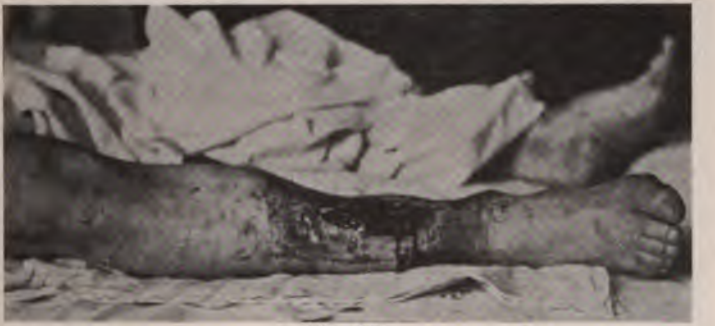


Fig. 694.

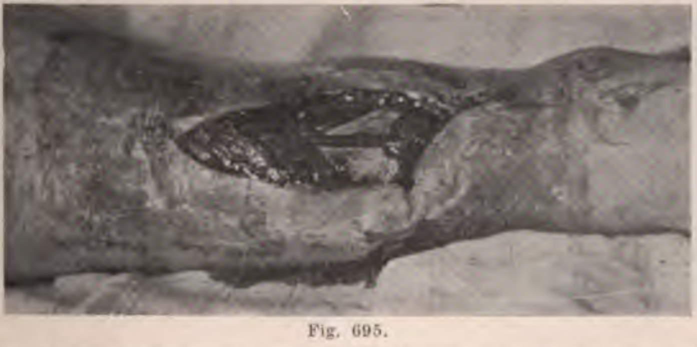


Fig. 695.

Figs. 694 and 695.—Severe compound, comminuted fracture of the bones of the leg. Hemorrhage free. Numerous globules of fat could be seen in the blood as it flowed from the wound having escaped from the tissues of the medullary cavity. These globules of fat in the blood remind one of the cases of fat embolism sometimes encountered in fractures. The lower plate (Fig. 695) is a closer view of the same case after the blood has been sponged away so the fragments of the tibia may be seen.

comes cold and lifeless and is later followed by gangrene. Symptoms of nerve injury are rare.

Diagnosis.—The symptoms are, as a rule, pronounced and there is little difficulty in recognizing the fracture. The deformity is usually so characteristic that a diagnosis can be made by inspection alone. The details of the fracture, however, are often impossible to determine without the aid of the X-ray. Isolated fracture of the fibula may go unrecognized unless a careful examination is made. The significant fact, when the fibular shaft alone is fractured, is that pressure on the shaft of the bone produces pain at the site of the break rather than at the point of pressure.

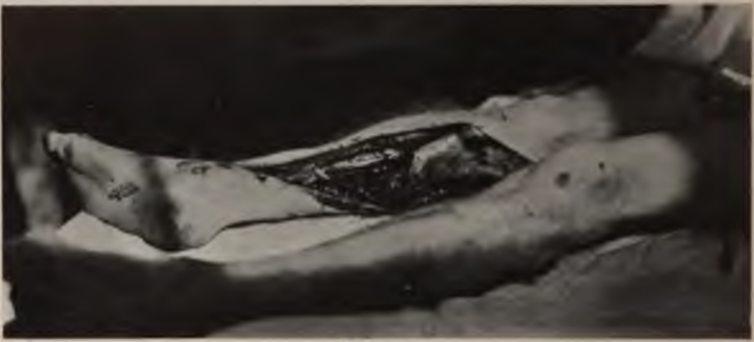


Fig. 696.

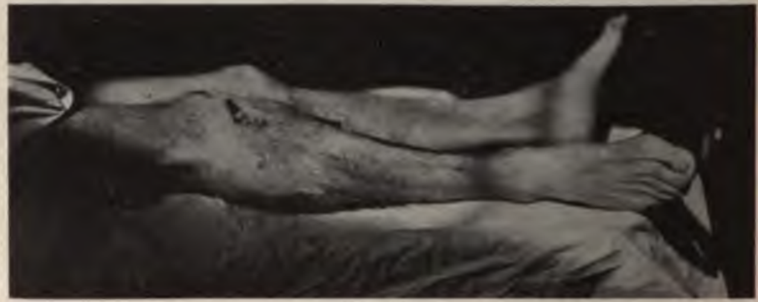


Fig. 697.

Figs. 696 and 697.—Severe, compound fracture of the tibia and fibula in their upper thirds. Upper end of lower tibial fragment is displaced upward and outward and lies just under cover of the skin. Extreme laceration and damage to the soft tissues. It is this type of fracture which usually requires amputation. The opening in the skin is the result of trauma at the time of the accident. Note the flail-like attitude of the leg below the fracture.

Treatment.—The emergency treatment of fractures of the leg is of considerable importance. Some form of temporary splint should be employed in transporting the patient from the scene of the accident to the hospital or home. The greatest care should be exercised to avoid converting a simple fracture into a compound one.

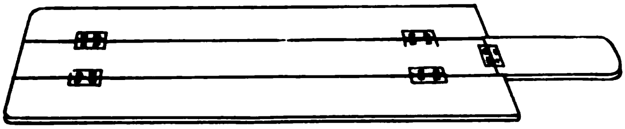


Fig. 698.—Folding fracture-box laid open.

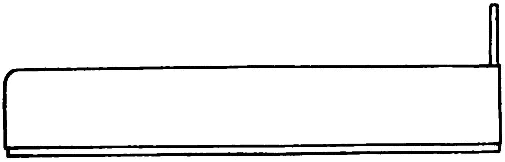


Fig. 699.—Same closed.

This may be easily done as the patient is being moved, or during careless manipulation of the leg. The less the parts are disturbed at this time the less pronounced will be the traumatic reaction, during the following week.

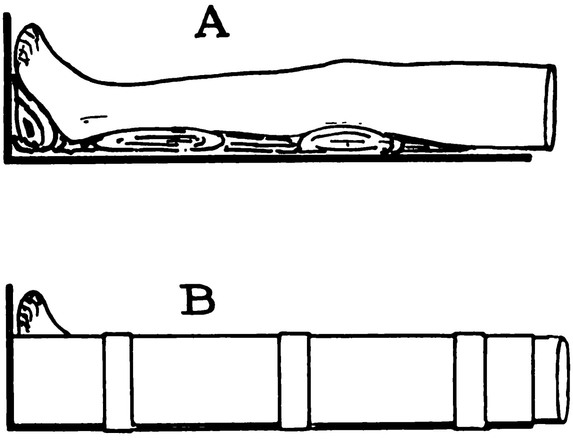
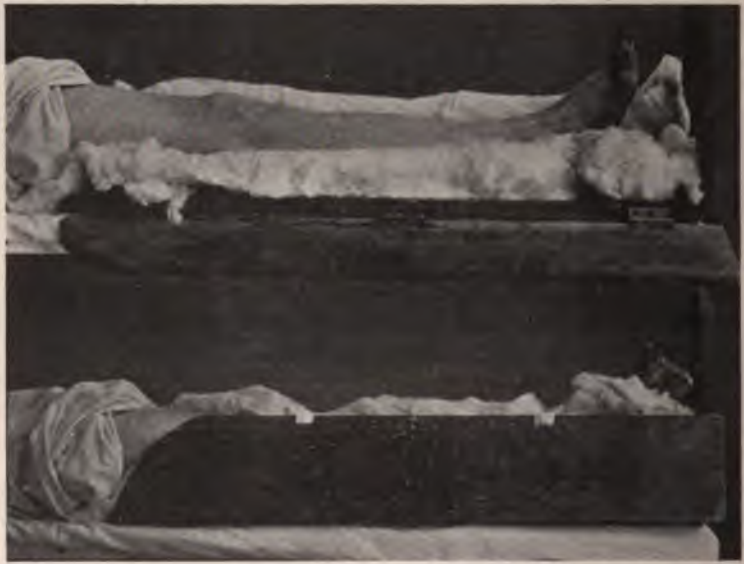


Fig. 700.—(A) Padding in fracture-box to conform to the posterior aspect of the leg. (B) Fracture-box closed and sides held in position with three strips of adhesive plaster.

In the reduction of fractures of the leg an anesthetic should be employed to relieve the pain and overcome muscular spasm. If the foot is grasped above the ankle and strong traction exerted while an assistant makes counter-traction just below the knee, it will usually be possible to return the fragments to their proper relations without great difficulty. Coaptation pressure on the fragments may be necessary and in transverse fractures angulation of the leg at the seat of the break may be required before an engagement of the fractured surfaces can be had. Pressure should not be made directly over the prominent end of a fragment lest the condition be rendered compound by penetration of the skin from within. It is common in spiral and oblique fractures to see recurrence of deformity take place as soon as the foot is released, and it is this type of break which most needs operative treatment and internal fixation.



Figs. 701 and 702.—Leg is seen in fracture-box with proper padding in place and side of box let down for inspection and readjustment of dressings, and again with fracture-box closed and fastened.

The treatment of fractures of the leg varies according to the amount of trauma and laceration sustained by the soft tissues and the facility with which the fragments can be held in reduction. During the first week or ten days the leg should be immobilized in some form of temporary splint which will steady the parts and yet allow perfectly for frequent inspection and adjustments, during the onset and subsidence of swelling. A number of appliances, varying in detail, though the same in principle, have been employed during this period for the temporary treatment of fractures of the leg. The fracture-box, pillow splint, posterior gutter splint of plaster, Du Puy splint, etc., have all been successfully used, and it is largely a matter of preference with the surgeon which of these methods of fixation is employed. The author has used both the pillow splint and the fracture-box with considerable satisfaction. The fracture-box is made of four pieces of wood as shown in Figs. 698 and 699. The inside of the box is well padded with cotton batting to fill in the spaces between the leg and the walls of the box. The sides of the box should be hinged so they can be lowered for inspection of the limb and readjustment of the padding. The pillow splint is made by placing the leg longitudinally on a pillow, which is then folded up on either side of the leg and held in position by encircling straps of adhesive, bandages, or ordinary straps with buckles, either of canvas or leather. If three splints are placed in position before the straps are tightened the whole appliance will be rendered much more rigid. These splints should be of light wood three and a half to four inches in width and should be placed between the straps and the pillow, one on either side and

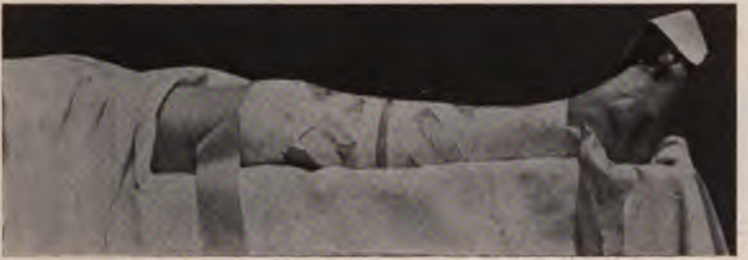


Fig. 703.

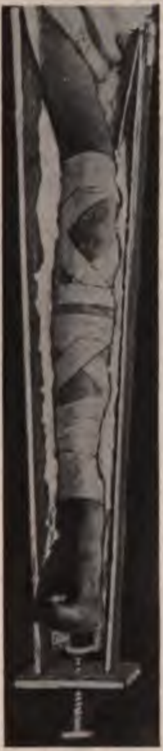


Fig. 704.

Fig. 703.—Adhesive plaster applied for traction and counter-traction with the short Desault splint. Adhesive on upper part of leg is applied to pull upward while that on the lower part of leg to pull downward when the splint is in position.

Fig. 704.—Short Desault splint in position, with padding about leg. Tightening the screw at the foot of the splint affords traction and counter-traction.

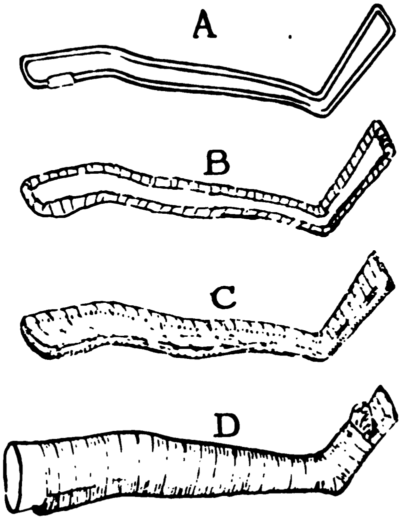


Fig. 705.—Cabot posterior wire splint. *A*. shows wire bent to conform to shape of leg. *B*. shows same padded and bandaged. *C*. shows same after space has been filled in by bandaging. *D*. shows splint applied to leg and bandaged in position.

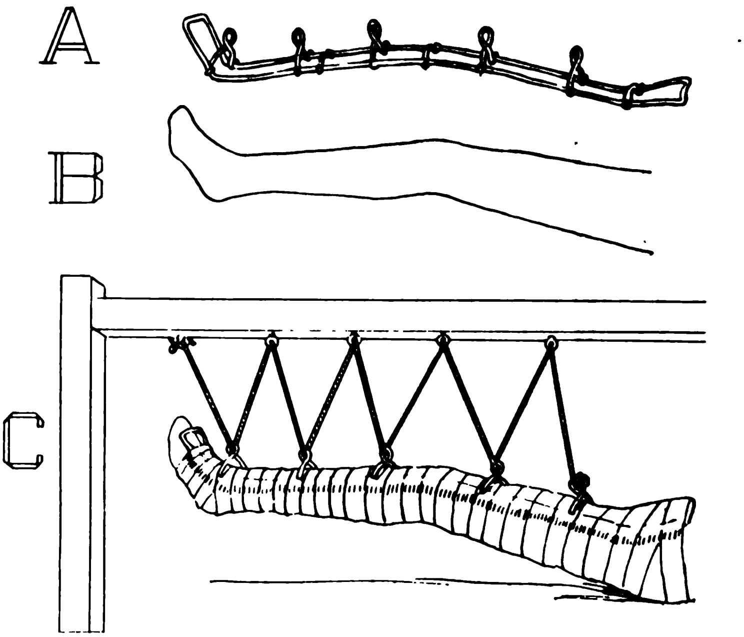


Fig. 706. N. R. Smith's suspension splint. *A* shows wire splint bent to conform to anterior surface of leg *B*. *C*. shows splint applied and leg suspended.

the third posteriorly. The pillow splint and fracture-box are as good as any and can be improvised even under unfavorable surroundings. The Cabot posterior wire splint and side splints are a favorite method with some surgeons. The fragments should be brought into alignment with the least possible manipulation as the leg is being placed on the temporary splint. Oblique and spiral fractures are common in the shaft of the tibia and it may be necessary to control the overriding deformity during this time, especially if the pointed end of one of the fragments threatens to perforate the skin, as is not infrequently the case. Under these circumstances an extension apparatus should be applied to the foot. This is often a difficult matter if the materials

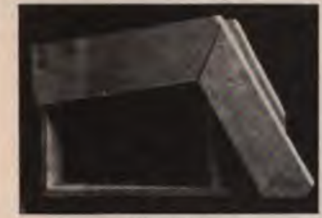


Fig. 707.

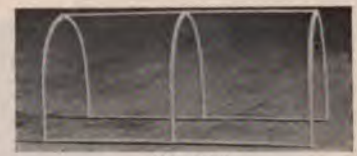


Fig. 708.

Fig. 707.—Elevated fracture-box. Of advantage in cases in which circulation of leg is much injured or in which flexion is required to maintain reduction. It is difficult, however, to render this form of box stable in bed.

Fig.. 708.—Cradle used to prevent bed clothes from resting on injured member.

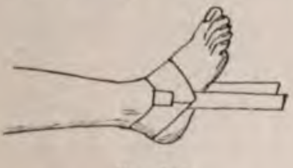


Fig. 709.

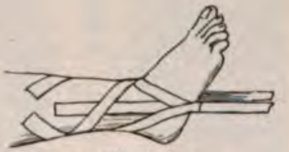


Fig. 710.

Figs. 709 and 710.—Methods of securing traction on fractures near the ankle by means of adhesive straps.

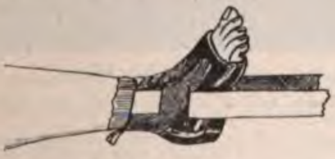


Fig. 711.

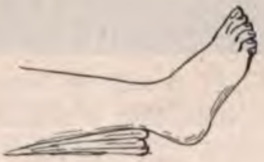


Fig. 712.

Fig. 711.—Old shoe with toe cut out and adhesive straps for obtaining extension.

Fig. 712.—Method of relieving the heel from pressure.

used are the same as those employed in Buck's extension, in fractures of the hip. Adhesive plaster when applied to the foot and ankle is likely to irritate the skin, because of the small area to which it can be attached. The author has found the following method very satisfactory in instances in which extension was found necessary. The patient's shoe is cut so that the "upper" is divided from the sole. Slits are then cut in the sides of the "upper" and adhesive straps passed through them to be carried below the foot to a spreader, the same as employed in Buck's extension. The upper is then placed on the foot, the lacings tightened and a weight attached to the cord after it has been passed through a pulley secured to the foot of the bed. Six, eight or ten pounds will usually

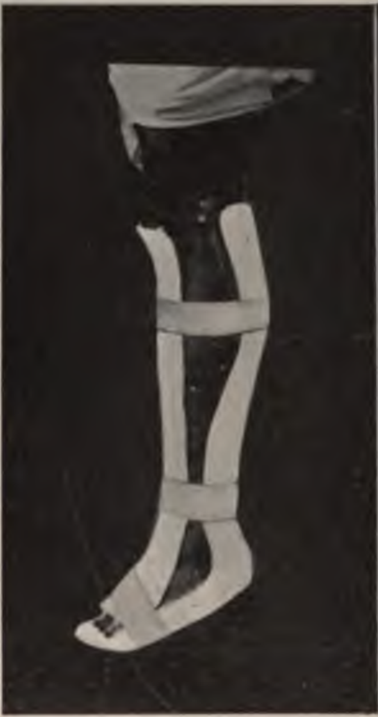


Fig. 713.

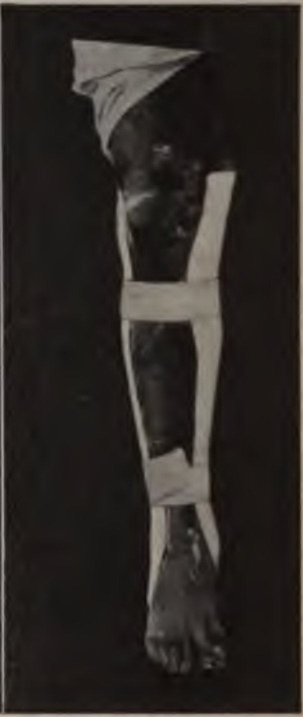


Fig. 714.

Fig. 713.—Anterior and posterior plaster splints applied to leg and held in position by encircling straps of adhesive plaster.

Fig. 714.—Plaster stirrup. The two side splints are made of one continuous piece of gauze which passes under foot. As a permanent dressing this splint is probably the most efficient and satisfactory in fractures of the leg.

suffice in correcting the deformity but the amount of weight employed should be governed entirely by the degree of muscular spasm to be overcome. Extension can be exerted in this way without irritating the foot and ankle during the time it is fixed on the temporary splint; counter-extension is had by raising the lower extremity on an incline plane or by raising the foot of the bed. Instead of splints, sand bags may be placed on either side of the leg and will serve the purpose well in steadying the parts.

It is often impossible to forecast the degree of traumatic reaction which will follow in a given case and it is therefore best to postpone the application of a permanent splint until this reaction has passed. The tension produced by the swelling, the internal laceration of soft tissues by the fragments at the time of injury, and the not infrequent venous thrombosis about the site of the fracture are conditions tending to impede circulation and demand dressings which do not constrict the leg. The plaster cast has been extensively used in the early treatment of fractures of the leg and good results have attended its use, yet the author feels that it is an unsafe appliance and is inferior in every way to the plaster stirrup or plaster splints. With either plaster splints or the plaster stirrup the dressings may be tightened or loosened as the occasion demands and during the entire course of the case a strip of skin, extending the length of the leg, is open to inspection. The plaster cast is much safer during the later half of the after-treatment and forms a good method of fixation for ambulatory treatment.

Isolated fractures of the tibia are rarely followed by much swelling, and fracture of the tibia alone is usually productive of a much milder traumatic reaction than occurs when both bones of the leg are fractured. The surgeon is usually able to estimate, with more or less accuracy, the degree of traumatic reaction to follow in a given case. Occasionally, however, cases are encountered which promise little in the way of swelling when first seen, and yet a few days later show the most marked symptoms. If such a case is wearing a permanent dressing of the nature of a plaster cast, great damage may be done to the leg before either the surgeon or the patient realizes the condition.

Numerous modifications of splints (such as the Desault and plaster traction splints) have been devised to maintain reduction by means of extension and counter-extension until the fragments have become firmly enough united to prevent displacement. These appliances are well enough as a permanent dressing, in instances in which operation is contraindicated because of disease, age or lack of surgical facilities, but under ordinary circumstances they are to be considered as obsolete and to be discarded in favor of operative methods with direct fixation of the fragments.

The treatment of compound fractures of the bones of the leg is essentially operative, at the present time, and with the vastly better results obtained in this way, there can be nothing but censure for non-operative methods, provided there are no constitutional contraindications and surgical facilities are available. (See "Operative Treatment," below.) A common and serious mistake in the treatment of compound fractures in this region is to effect an immediate reduction as soon as the case is seen, often on the street or in the factory. This procedure has probably been responsible for the loss of many legs which could otherwise have been saved. The ends of the fragments projecting through the skin must be considered infected and if an immediate reduction is performed the patient will be fortunate, to say the least, if the entire tract does not become septic, with the usual disastrous train of symptoms following. Instead of attempting immediate reduction, the wound and exposed bone should be covered with a sterile dressing and the patient removed to surroundings in which proper surgical procedures can be carried out. (See "Treatment of Compound Fractures," page 789.)

Operative Treatment.—There are four sets of circumstances which commonly call for operative treatment. First, to accomplish and maintain reduction in recent cases in which non-operative methods have failed; second, in the treatment of compound fractures; third, when non-union is present, and fourth, for the correction of old fracture deformities.

A large proportion of closed fractures of the leg demand operative intervention to secure the best results. The best time for operation in simple cases is after the traumatic reaction has subsided, which will be at the end of a week or ten days. The most aseptic technique should be followed and other precautions observed such as are mentioned on page 754 under the heading of "Open Treatment of Fractures." A longitudinal incision should be made, preferably to the outer side of the midplane of the leg, so that the external surface of the bone will be exposed. It is not advisable to make the incision opposite the internal surface of the tibia, since this face of the shaft is subcutaneous. In difficult cases two incisions may be made, one as already described and the other opposite the internal border of the bone on the inner aspect of the leg. Traction and direct manipulation of the fragments will accomplish reduction and occasionally it may be possible to obtain a solid engagement of the serrated surfaces, thus obviating the necessity of direct fixation. In most instances, however, in which operation is indicated, it will be found necessary to resort to some form of internal fixation to prevent recurrence of deformity. A very satisfactory method of securing the fragments, and one which will serve the purpose in most oblique and spiral fractures, is shown in Fig. 717. This consists in passing two wires about the shaft of the bone. The distance between them should be at least an inch, to secure the proper leverage. In some instances the Lane plate can be used to advantage. Transverse fractures can often be engaged in such a manner that no internal fixation is necessary. If a plate is used it is preferable to place it on the external surface of the shaft so that it will not be subcutaneous. In knotting or twisting wire, the twists or knots should be placed on this same surface. With the wires or plate in position the strength of the fixation should be gently tested to see that the fragments are solidly enough held. It should be possible to raise the foot by the

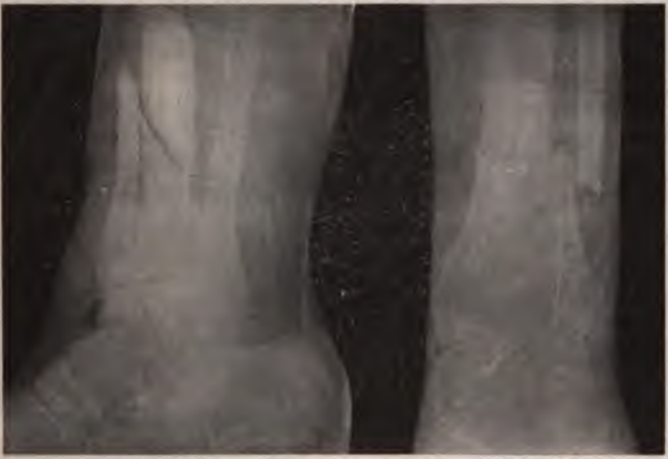


Fig. 715. Fig. 716.

Figs. 715 and 716.—Lateral and antero-posterior views of comminuted fracture of tibia. Transverse fracture of fibula.

heel without disturbing the relative positions of the fragments. When the internal fixation has been completed and tested the wound should be closed and a small drain of silkworm gut placed in position to allow the escape of blood and serum during the first twenty-four or forty-eight hours. A heavy plaster stirrup should be applied before the patient comes out of the anesthetic. A quick drying plaster should be used so that the stirrup may be well set

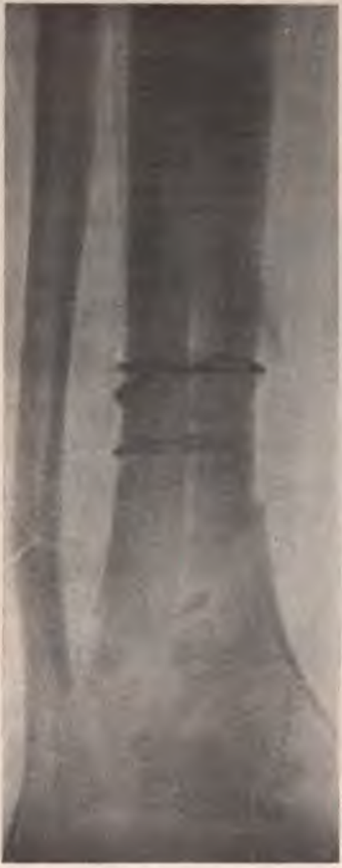


Fig. 717.

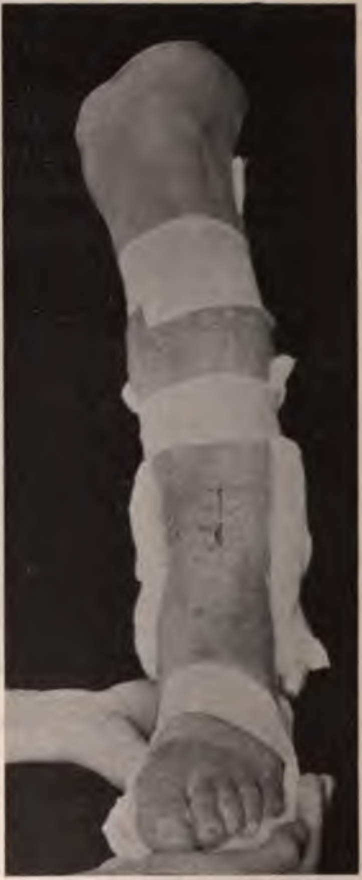


Fig. 718.

Fig. 717.—Same case as shown in Figs. 715 and 716. X-ray plate made three weeks after operation in which the bones were wired in two places. Aseptic healing and ultimately perfect function.

Fig. 718.—Same leg shown on posterior plaster splint. The anterior splint has been removed to dress wounds. (See Fig. 713.)

before the patient leaves the operating room. If a sheet, narrowly folded lengthwise, is passed once around the thigh just above the knee, and the ends secured to the side rails of the bed, it will prevent the patient moving the lower extremity while coming out of the anesthetic, and will be of valuable assistance to the attendant during this time. The leg should not be covered with the bed clothes during the first twenty-four hours following operation, so that the plaster may become thoroughly hardened and dried out. Failure to observe this precaution will probably necessitate the reapplication of the dressing, to say nothing of the possibility of damage to the limb through lack of support.

In compound cases the patient should be taken to the operating room as soon following the accident as possible. An anesthetic should be given, the skin surrounding the wound painted with five percent iodine and the incision enlarged if necessary. The wound should be irrigated with a few gallons of sterile salt solution. Completely detached fragments of bone should be removed and the main fragments brought into as good alignment as possible. Devitalized tissue should be trimmed away and oozing controlled by hot salt solution. Active bleeding from small arteries should be stopped by torsion, if possible, rather than by ligature. Internal fixation of the fragments at this time is contraindicated regardless of the material used. The freshened surfaces of the wound should be approximated and a small drain of silkworm gut left in position to allow the escape of blood and serum. Dressings are then applied to the wound, the leg covered with a layer of sheet cotton and a plaster stirrup employed as already described. When the patient is transferred to the bed the leg should be well elevated and an ice cap (one that does not leak) is placed on the anterior aspect of the leg in the region of the fracture. An attempt should be made during the operation to secure as accurate reduction as possible, yet it should be remembered, in these cases, that accurate reduction at this time is not the essential. The most important factor is to obtain healing of the wound which renders the fracture compound. If the position of the fragments is bad, a second operation may be done at some later date, after the wound has healed and the surgeon is free to work in an aseptic field. This can usually be done at the end of ten days or two weeks. If suppuration and infection follow, in spite of the measures just advised, the fracture must be treated along general surgical lines with free drainage, etc. The number of infected cases, however, following this line of procedure will be surprisingly small as compared with the cases in which local applications of bichlorid of mercury and other useless antiseptics are the agents depended upon to prevent infection.

Operation may be indicated to correct old fracture deformities in which the poor alignment of fragments is accompanied by pronounced disturbance in function. In a case of this type the surgeon should not be overanxious to operate if the patient is showing any improvement whatever. The restoration of function may be greatly delayed and still the patient may ultimately obtain a serviceable member without surgical intervention. When operation is necessary the procedure is similar to that already described, with the addition of appropriate osteotomy to bring the fragments back into proper position.

When operation is called for because of non-union the first indication is to seek the cause of the failure in union. (See Chapter LXI.)

After-Treatment.—A great deal of care and attention is called for in the after-treatment to keep the patient comfortable and to see that the dressings are performing their proper function. Repeated adjustments will be necessary, especially during the time the leg is changing in size, with the onset and passing off of swelling. During the first week or ten days the leg should be inspected at least daily and readjustments made. Blebs should be opened after they have fully formed and the denuded surfaces dusted with boric acid or some other efficient dusting powder. These surfaces should receive the most careful attention and it must not be forgotten that the member may become infected through such an atrium, especially in the presence of low resistance in the surrounding tissues.

The sooner ambulatory treatment is instituted, following the subsidence of traumatic reaction, the better for the patient in general and the fracture in particular. In non-operative cases the patient may be gotten up on crutches within five or six days of the application of a permanent splint. When open treatment has been employed to accomplish reduction, a week should elapse following the operation, before the patient is allowed up. In compound cases the wound should be well healed and the fragments in good position for a week or more before ambulatory treatment is instituted. Complicated cases should remain in bed until the outlook is favorable and convalescence well established. The patient should be allowed up for only a few minutes during the first day. The time should be increased the second day, and so on during the following week until the limb can be held in the dependent position without undue swelling and pain. During this time he will gain control of the crutches, and the annoying sensations in the leg, attendant upon the erect position, will gradually grow less and finally disappear. At the end of nine or ten weeks the foot may be placed on the floor as the patient walks with crutches. During the following three or four weeks weight bearing should be gradually resumed. During this time the surgeon should watch the leg carefully for signs of a weak callus. The slightest bowing or shortening of the leg demands immediate cessation of weight bearing. Swelling is often persistent and pronounced and should be treated by daily massage and immersion of the leg in hot water once or twice a day. An elastic stocking worn during the day will aid materially in controlling this swelling. The older the patient the longer the time necessary for the formation of firm weight bearing callus. In the very aged it may be impossible to obtain union at any time. In the exceptional case in which the surgeon may be in doubt as to the best time for the resumption of function, an X-ray plate will afford the desired information concerning the condition and progress of callus formation.

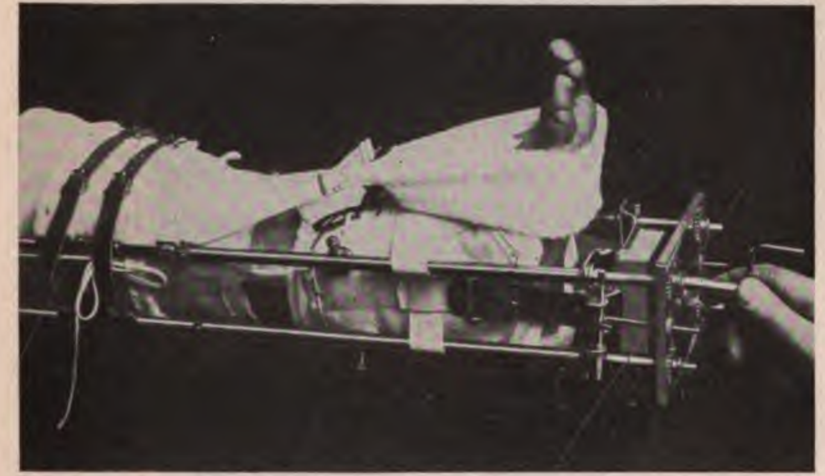


Fig. 719.—Ambulatory pneumatic splint as used in fractures of the leg. Note the extension mechanism at the end of the splint.

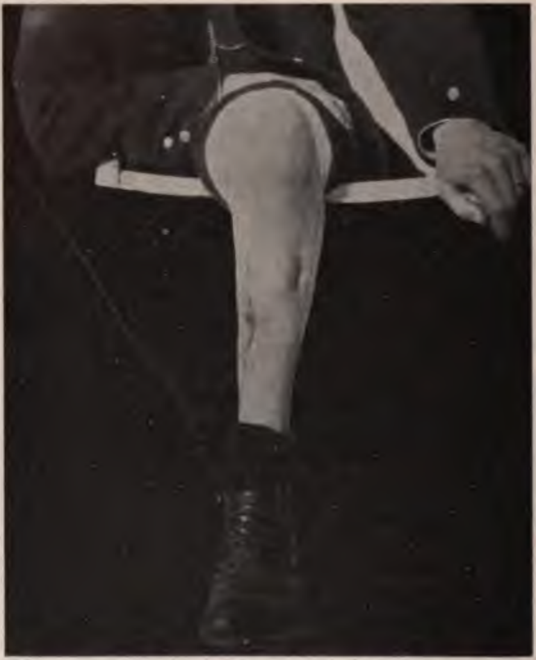


Fig. 720.—Old fracture of the tibia and fibula with discharging sinus eight years later. The condition has been an intermittent source of trouble during the entire eight years. This is a good example of a type of case requiring operation for the removal of necrotic bone.

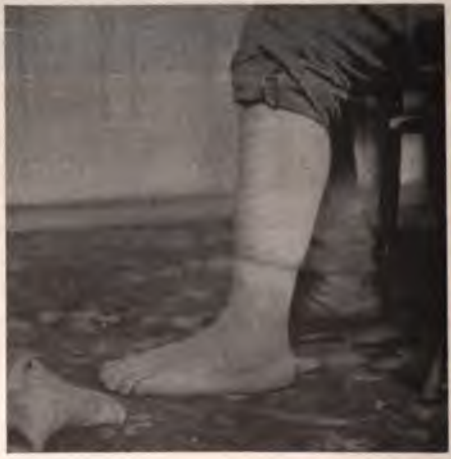


Fig. 721.—Picture taken to show the swelling which so frequently persists following fractures of the bones of the leg especially with patients past middle life. Picture taken some months following the accident. The ring about the leg corresponds to the upper end of the elastic stocking.

Prognosis.—The prognosis in fractures of the leg is extremely variable and depends largely on the associated injuries to the soft tissues and whether or not a compound fracture becomes infected. Persistent swelling is common and may last for years. It is dependent on the damage done to the circulation at the time of the injury and on the development of venous thrombosis following the accident. The more severe these conditions, the more pronounced and persistent will be the swelling when function is resumed. Pain in the leg may persist for months or even years following the accident. Considerable disturbance in function usually follows vicious union of the fragments and is due to the mechanical strain imposed on both muscle and bone by this faulty position. The more perfect the apposition of the fragments and the less the damage to soft tissues at the time of the accident, the less pronounced will these annoying sequelæ be. The percentage of cases in which perfect and prompt restoration of function occurs, has greatly increased since the advent of open treatment for the accurate correction of deformity.

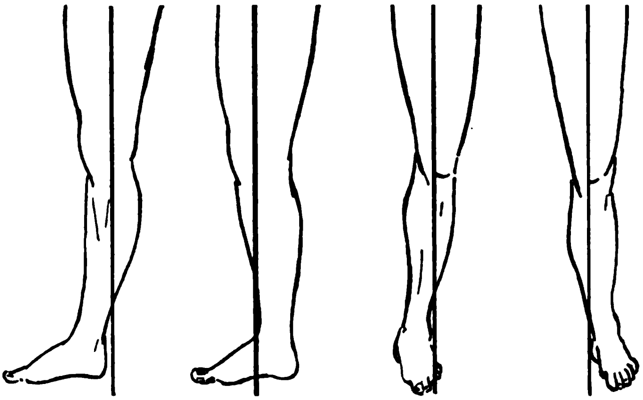


Fig. 722. Fig. 723. Fig. 724. Fig. 725.

Figs. 722, 723, 724 and 725.—Show the mechanical disturbances which follow union with deformity. When the leg diverges from the weight-bearing line the leg will be mechanically "off" and as a result there will be more or less permanent disturbance in function.

In compound infected cases, sinuses may persist until the necrotic bone from which they lead is removed by operation. Refracture of the bones of the leg may occur if sufficient strain is sustained before the callus becomes thoroughly hardened. Refracture is through the callus and not the fragments. About one-half to two-thirds the time required for union in the original break is necessary for union in a fractured callus. Embolism from a detached portion of thrombus or a fat embolus may produce immediate death. Infection in compound cases may result in the loss of the leg, or if severe, even death. Destruction of the circulation in severe crushing injuries calls for immediate amputation.

CHAPTER XLVI.

POTT'S FRACTURE.

Pott's fracture is both a fracture and a dislocation, and although it is usually included under the heading of fractures, yet it is probably more in accordance with the pathology of the condition to consider it as a dislocation complicated by fracture.

Aside from fracture of the fibula, Pott's fracture is the most common injury of importance occurring in this region, and because of this frequency and the poor results so often seen following its improper treatment, it will be taken up under a special heading.

Surgical Anatomy.—There are three bones entering into the formation of the ankle joint: the tibia, fibula and astragalus, and the disposition of these three bones is of great importance surgically. The trochlear surface of the astragalus fits the articular surface of the lower end of the tibia and is held in place laterally by the malleoli. Lateral motion between the astragalus and tibia is prevented by the tight, firm, mortise-like formation of the tibia and fibula. The two latter bones are held together by the lower tibiofibular ligaments, the most important of which is the inferior interosseus, which passes between the contiguous rough surfaces of the tibia and fibula. These ligaments are so strong that separation of the two bones rarely takes place without fracture of either the tibia or fibula. The lateral ligaments are also of great strength and are more likely to tear away their attachments than to suffer rupture. They bind the astragalus and calcaneum to the lower end of the tibia but have little to do with the limitation of normal flexion and extension. The anterior and posterior ligaments are thin, loose and lax, and are not brought to a tension until the ankle either comes to extreme flexion or extension. When the foot is depressed to its limit of motion the anterior ligament becomes taut and in like manner the posterior ligament is brought to a tension when the ankle is dorsally flexed. Distention of the joint is first noted in the bend of the ankle where the thin anterior ligament is pushed forward by the fluids within the articular cavity. The outer malleolus is longer and extends to a lower level than the inner malleolus. If the normal alignment of the bones of the leg with the astragalus and calcaneum is observed it will be noted that the heel rests on the ground outside of the median plane of the leg (see Figs. 726 and 727). It will be readily seen, therefore, that violence applied in a longitudinal direction, such as is sustained in a fall from a height in which the patient lands squarely on the foot, will tend to displace the foot outward as well as upward. It is apparent that this displacement cannot take place without producing fracture and ligamentous rupture. The points of least resistance will be found in the fibula just above the lower tibio-fibular articulation and in the internal lateral ligament of the ankle joint or its attachment to the inner malleolus. When these conditions prevail we have the typical Pott's fracture as shown in Figs. 729 to 731. Compare the positions of the bones as indicated in Fig. 729 with the clinical appearance of the deformity as shown

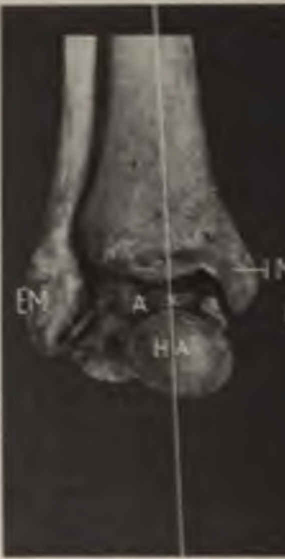


Fig. 726.

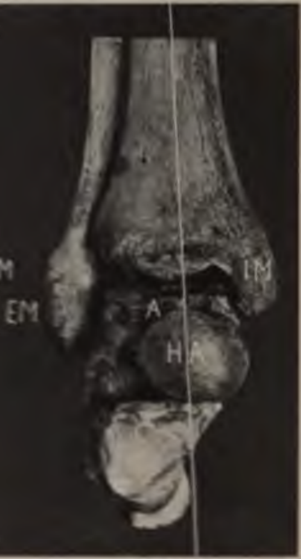


Fig. 727.

Fig. 726.—Shows the mortise formed by the tibia and fibula into which the astragalus fits. *E.M.*, External Malleolus; *I.M.*, Internal Malleolus; *A.*, Astragalus; *H.A.*, Head of Astragalus.

Fig. 727.—Same view of ankle with calcaneum in position. A line drawn through the long axis of the tibia falls to the inner side of the heel, hence the frequency of talipes valgus in injuries of this region. *E.M.*, External malleolus; *I.M.*, Internal malleolus; *A.*, Astragalus; *H.A.*, Head of Astragalus; *C.*, Calcaneum.

in Figs. 740 to 745. Outward rotation of the foot, on a more or less vertical axis passing through the astragalus, probably plays a part in the production of many Pott's fractures, by prying the malleoli apart. When this type of strain enters into the causative trauma the fibular fracture is usually spiral instead of transverse. In addition to the lesions just mentioned we may find either the anterior or posterior margins of the lower tibial surface broken off and displaced.

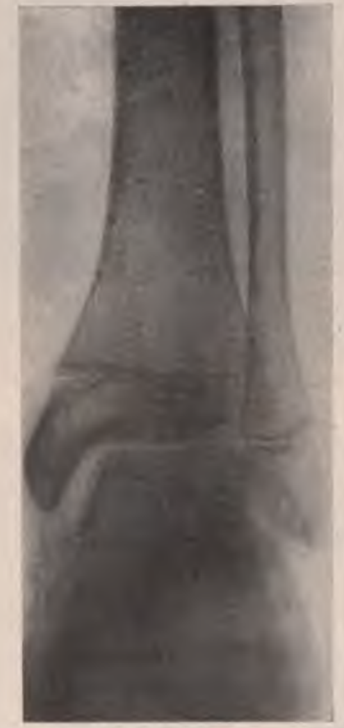


Fig. 728.—Normal ankle showing the epiphyses at thirteen years of age.

The constant element in Pott's fracture consists of a fracture of the fibula within two or three inches of the lower tibio-fibular articulation. The variable element is at the inner malleolus, where either the deltoid ligament is ruptured or the tip of the inner malleolus torn away. Numerous descriptions have been given of the exact manner in which a Pott's fracture is produced and the order in which the different lesions take place; as a matter of fact

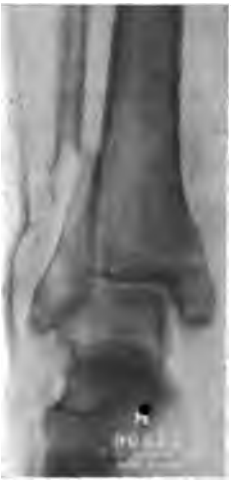


Fig. 729.

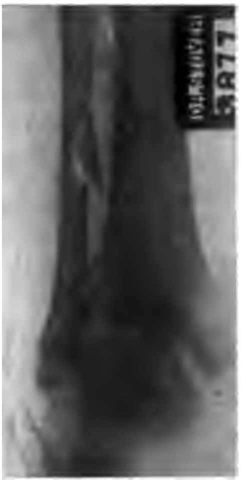


Fig. 730.

Fig. 729.—Pott's fracture with the usual outward displacement. Note the space between the inner malleolus and the astragalus.

Fig. 730.—Variant of Pott's fracture. Incomplete fracture of fibula with avulsion of portion of tibia, corresponding to insertion of lower tibio-fibular ligament.

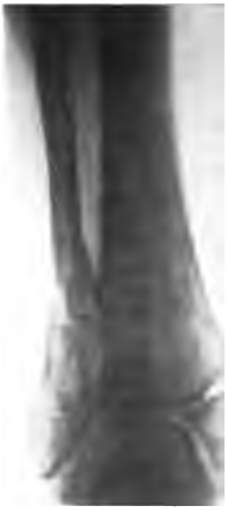


Fig. 731.

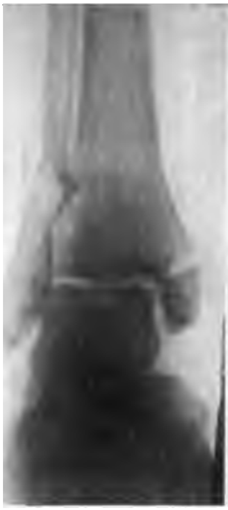


Fig. 732.

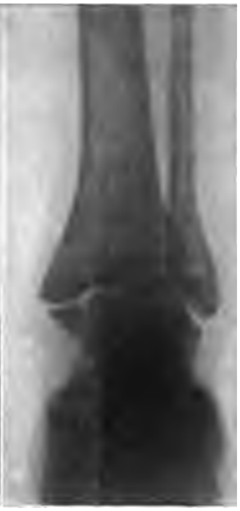


Fig. 733.

Fig. 731.—Pott's fracture. Comminution of fibula and fracture of inner malleolus.

Fig. 732.—Pott's fracture. Comminution of fibula and fracture of inner malleolus.

Fig. 733.—Variant of Pott's fracture. Fracture of inner malleolus and diastasis of lower tibio-fibular joint. The separation previously existing between the lower ends of the tibia and fibula has been corrected at the time of reduction, and hence the diastasis is not apparent in the Röntgenogram.

it is difficult to state whether the internal lateral ligament ruptures before the fibula breaks, or whether the bone breaks before the ligament ruptures. Probably the latter mechanism obtains in most cases. Instances of Pott's fracture by inversion of the foot have

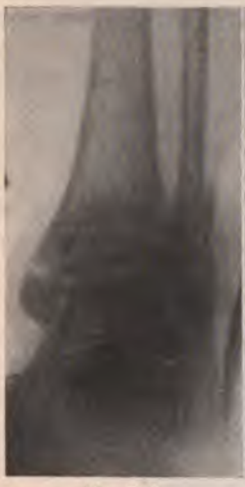


Fig. 734.

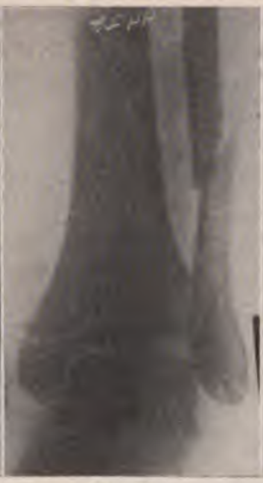


Fig. 735.

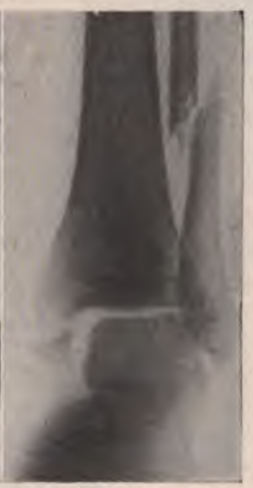


Fig. 736.

Fig. 734.—Pott's fracture. Fracture of inner malleolus.
Fig. 735.—Pott's fracture. Fracture of inner malleolus.
Fig. 736.—Pott's fracture with fracture of inner malleolus.

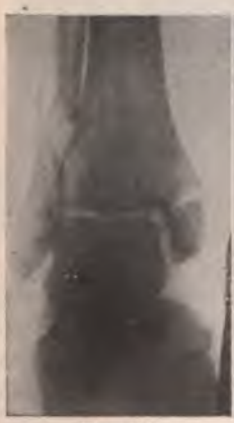


Fig. 737.

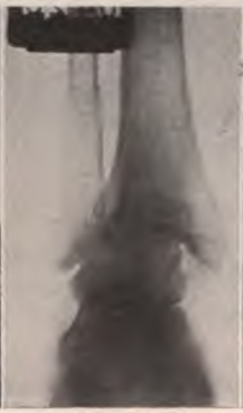


Fig. 738.

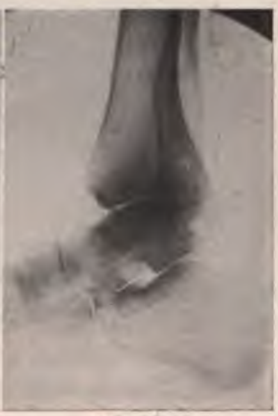


Fig. 739.

Fig. 737.—Pott's fracture. Comminution of fibula and fracture of inner malleolus.
Fig. 738.—Old Pott's fracture. Incomplete reduction.
Fig. 739.—Lateral view of old Pott's fracture. Note old fracture in fibula.

been reported in which the shaft of the fibula was fractured by the inward pull on the external malleolus, and the inner malleolus fractured by direct pressure of the astragalus. The production of Pott's fracture by this mechanism is rare. Separation of the lower ends of the tibia and fibula have occurred as a result of rupture of the tibio-fibular ligaments or a wrenching off of their bony attachments, this condition however cannot be properly called a Pott's fracture. It will be considered under dislocations of the ankle. When the lateral displacement of the foot is great the inner malleolus (or what is left of it after the tip has been avulsed) may be forced through the skin, thus rendering the condition compound and exposing the ankle-joint to infection.

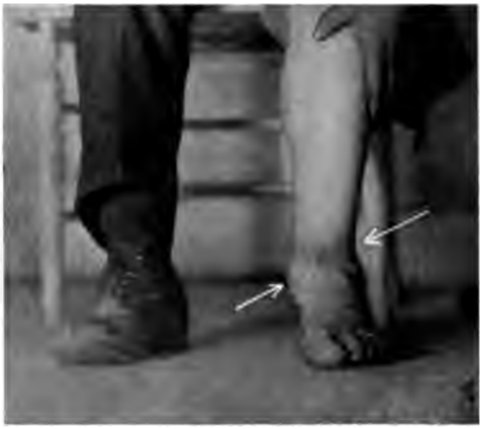


Fig. 740.—Pott's fracture of the left ankle a few minutes following injury. Deformity moderate though characteristic. Note the outward displacement of the foot and the prominence of the inner malleolus. The difference in the contour of the two ankles may be readily recognized even though the shoe on the right foot has not been removed. Inner arrow points to ruptured deltoid ligament. Outer arrow indicates level of fibular fracture.

An "inverted" or "reverse" Pott's fracture is an inward fracture-dislocation of the ankle and will be discussed under the heading of "Dislocations of the Ankle," on page 684. The treatment of this condition is essentially different from that of Pott's fracture and the two lesions should not be confounded.

Symptoms.—Immediate and complete loss of function, pain and characteristic deformity, following an injury to the ankle, are the typical symptoms occurring in Pott's fracture. The foot is in a position of more or less pronounced eversion and the inner malleolus is more prominent than normal. It is often impossible to elicit crepitus but abnormal mobility will be recognized when the lateral stability of the ankle is tested. If the foot is viewed laterally an abnormal prominence of the heel will usually be noted and the dorsum of the foot will be found somewhat shortened. Measurements should be made from the anterior edge of the lower tibial articular surface to the base of the phalanx of the great toe, and compared with the opposite foot. Swelling follows the injury rapidly and tends to mask the deformity. The ankle-joint becomes

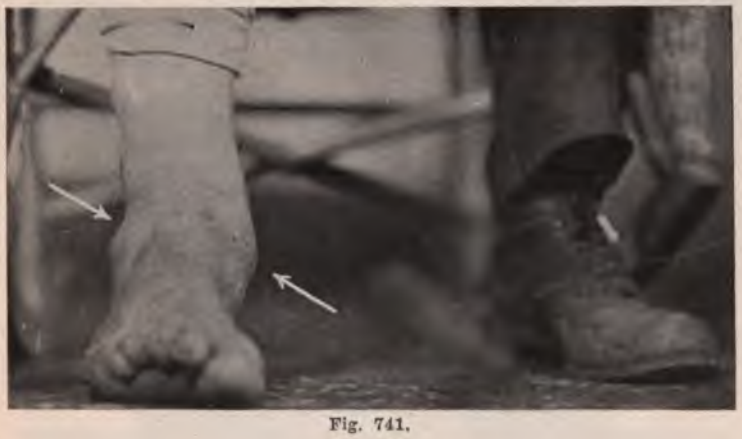


Fig. 741.

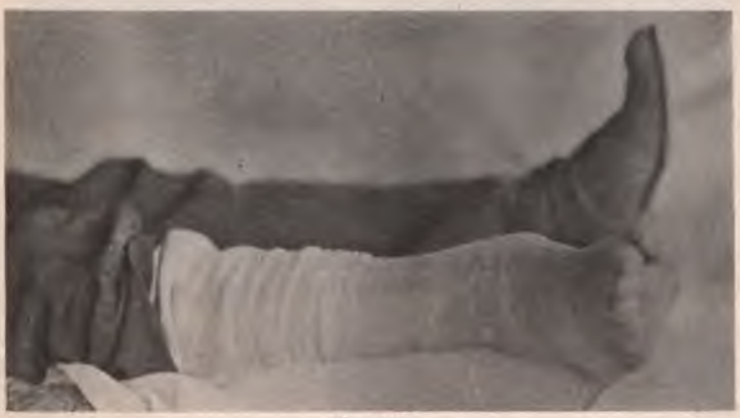


Fig. 742.

Figs. 741 and 742.—Simple Pott's fracture the result of a fall on the foot. Note prominence in region of internal malleolus and eversion of ankle, which is present in both upright and recumbent positions. Note also depression about one inch above external malleolus which corresponds to fracture in fibula. Photographed about twenty minutes following accident.

distended with blood and synovial fluid. The entire ankle is tender and painful, especially in the region of the fibular fracture and below the internal malleolus. Ecchymosis usually develops within the first twelve or twenty-four hours. If the fracture is allowed to go untreated or if the condition is not properly diagnosed and the deformity fully corrected, recovery takes place with the foot in eversion and backward displacement. This means great and permanent loss of function. There are two elements in the deformity; firstly, the eversion of the foot and secondly, the backward displacement, both of which tend to recur as soon as the parts are released.

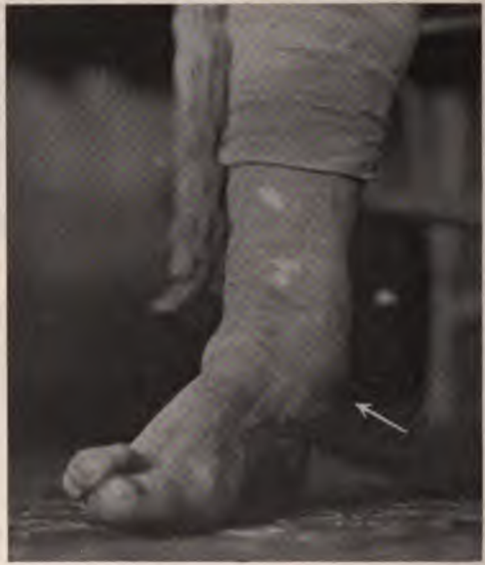


Fig. 743.—Another view of the case shown in Figs. 741 and 742.

Diagnosis.—There should be little difficulty in recognizing the condition, especially if seen before the swelling has become pronounced. The deformity is characteristic, as shown in the accompanying illustrations. The eversion, backward displacement, abnormal mobility, pain, loss of function and sometimes crepitus should enable one to recognize the condition as soon as seen. An X-ray plate, however, is of great value in determining the details of the injury and the presence of unusual complicating fractures when they occur. It is of especial importance in ascertaining the position of the fragments after reduction has been attempted. As previously stated the traumatic inflammatory reaction tends to mask the deformity, yet the disturbed alignment is generally apparent even when the swelling is extreme. In the usual supramalleolar fracture the break in the tibia may be recognized above the ankle-joint, and the malleoli are not spread as in Pott's fracture. In longitudinal splitting of the lower end of the tibia the diagnosis is sometimes difficult without the aid of the X-ray although it will often be possible to elicit an abnormal mobility not seen in Pott's fracture.

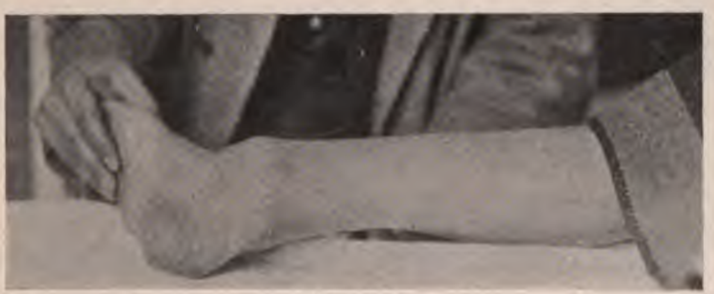


Fig. 744.

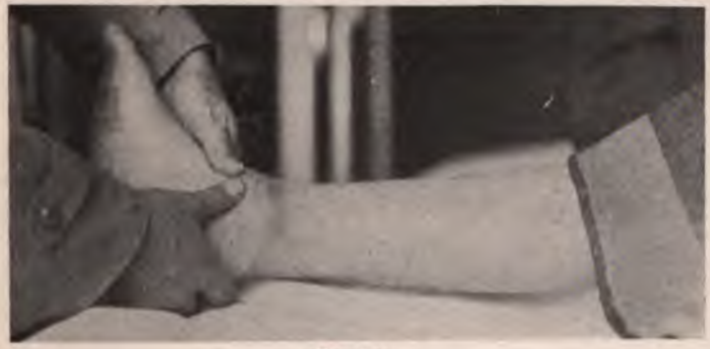


Fig. 745.

Figs. 744 and 745.—Recent Pott's fracture seen from behind. Note the outward displacement of the foot and the prominence of the inner malleolus. Deformity corrected by drawing the foot inward and forward.

Splitting off of a small portion of bone, including the tibial attachment of the lower tibio-fibular ligaments and a part of the lower tibial articular surface, may permit of independent motion between the malleoli, but is often particularly difficult to recognize unless a Röntgenogram is made.

There is no distinction to be made between outward dislocation of the foot and Pott's fracture; they are practically the same condition. In inward dislocation of the ankle the foot is displaced inward and the accompanying fracture in the fibula is at a lower level, while the fracture in the tibia is at a higher level, than is seen in Pott's fracture. In forward dislocations the foot is displaced forward and in backward luxations, backward instead of the typical outward displacement accompanying Pott's fracture.

In some instances the characteristic deformity of Pott's may be absent because of the ankle having been pulled back into position before the surgeon sees the case. The lateral stability of the ankle, however, is destroyed and when an attempt is made to displace the foot outward this fact is recognized and the typical deformity is produced.

Treatment.—The indications in the treatment of Pott's fracture are to correct the eversion and backward displacement of the foot, and to see to it that these two deformities are completely reduced and maintained in position until the callus formation and ligamentous repair are sufficiently strong to prevent recurrence.

As an emergency method Dupuytren's splint is particularly satisfactory but should be replaced by Stimson's plaster splints within a week.

The deformity should be corrected as soon as possible and measures instituted to control the inflammatory reaction which is to follow.

The recumbent position, elevation of the injured foot and the intermittent use of the ice cap over the seat of fracture will relieve the pain and control the swelling. If the trauma producing the injury was severe and the swelling is great it may be best to treat the fracture on a pillow splint for the first few days.

Dupuytren's splint.—A board as broad as the calf of the leg, and from one-fourth to five-eighths inches in thickness extends from below the knee to a point a few inches below the foot. It is heavily padded above the fracture with a folded sheet of sufficient thickness to allow complete inversion of the foot without the latter touching the splint (see Fig. 746). The lower end is notched so that turns of bandage may be secured to the end of the splint. The splint is fastened to the leg with bandages or strips of adhesive, the foot forced into inversion and held in position as shown in the accompanying illustrations. In this way the outward displacement is corrected and maintained in reduction. The backward deformity is more difficult to correct when this splint is employed. The foot should be pulled forward as the bandages are being applied, but the risk of subsequent backward slumping of the foot is considerable and requires constant watching. This method is of value as an emergency dressing, especially since the necessary materials are readily obtainable under almost all circumstances. After the splint is applied the patient should remain in the recumbent position with the injured member elevated on a pillow and the ice cap applied. The change in the size of the parts as a result of swelling, renders it inadvisable to employ a plaster dressing early in the treatment of Pott's fracture.

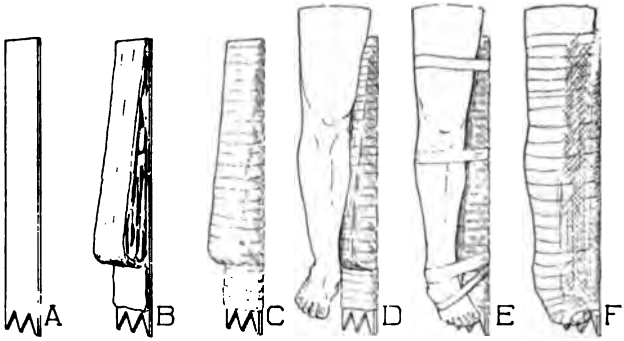


Fig. 716.—Shows the making and use of Dupuytren's splint for the treatment of Pott's fracture. This splint is most satisfactory as an emergency measure and during the acute traumatic reaction. *A.* shows board with notched lower end. *B.* shows padding applied, which is thickest at ankle. *C.* shows same bandaged in position. *D.* shows lower extremity in proper relation with splint. *E.* shows foot forced into adduction. *F.* shows bandages applied. Some of the turns passing over the foot are caught in the notched end of the splint, thus rendering adduction more firm. If the traumatic reaction is extreme it may be best to dispense with all forms of bandaging and treat the leg in a fracture-box or on a pillow splint for the first few days. (See Figs. 698 to 702 and 707.)

The Cabot posterior wire splint with side splints is a satisfactory dressing both in the early and late stages of the treatment of this fracture and has been used with considerable success by some surgeons. In the early stages, however, it has no advantage over Dupuytren's splint and interferes somewhat with the application of the ice cap. In the later stages it is not as perfect a method as is that of Stimson, in which the lateral and posterior plaster splints are used.

Stimson's plaster splints constitute the most satisfactory permanent dressing known for the treatment of Pott's fracture. The posterior splint, which is applied first, extends down the back of the leg and heel and under the sole of the foot to the toes. The lateral splint should extend from about the upper end of the fibula, down the external aspect of the leg, under the sole of the foot, over the dorsum to the external malleolus. These splints are best made of gauze folded and cut to the proper length and about four inches in width. If a twenty-five yard bolt of gauze, such as is found in the usual hospital supplies is available, the desired amount may be cut from it without waste and each splint is thus made of one piece. Each splint should be from twelve to eighteen ply, according to the size and musculature of the patient. These strips of gauze are soaked in plaster cream, wrung out and placed in proper position on the leg. The posterior splint is applied first and then the

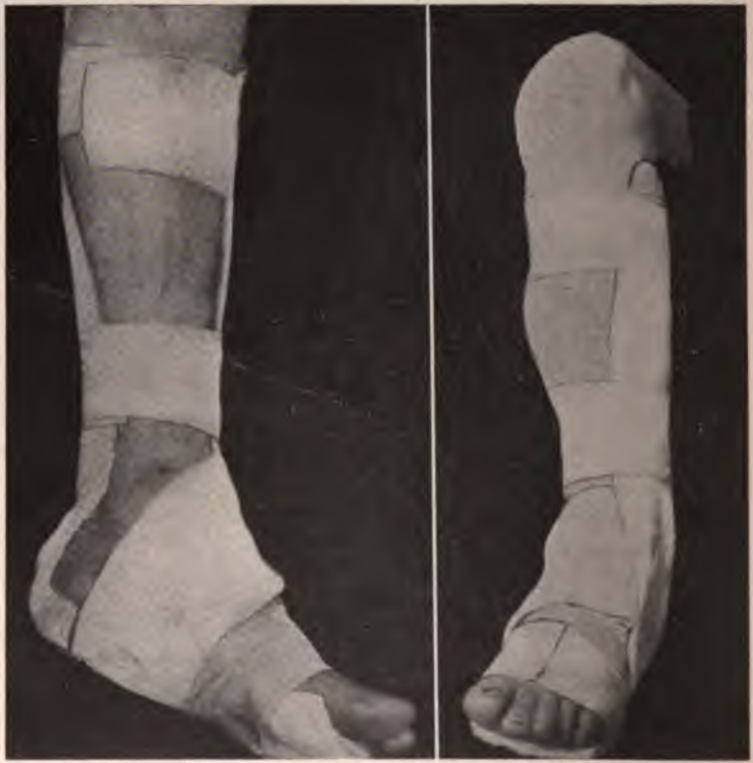


Fig. 747. Fig. 748.

Figs. 747 and 748.—Stimson's plaster splints applied to a Pott's fracture and held in position by strips of adhesive plaster. Note how the foot has been inverted and brought forward until the relations are normal. Results in this case were complete restoration of function and absence of deformity.

lateral splint. The lower end of the lateral splint, encircling the foot, should be overlapped by the straight portion on the outer aspect of the ankle (see Fig. 748). The splints are placed in position and brought quickly into snug position by a roller bandage. The surgeon then takes his place at the foot of the table and forces the foot forward and into adduction while the plaster is still wet. This attitude is maintained until the plaster has set sufficiently to maintain the proper reduction. During this time the weight of the foot and lower extremity rests on the heel in the surgeon's hand thus forcing the foot forward and correcting the usual backward displacement. Some cases may require more force than is exerted by the weight of the limb in overcoming this posterior deformity. A quick-setting plaster should be used, otherwise the holding of the foot in inversion will be unduly tedious. If the condition is compound the lateral splint may be applied to the inner side of the leg with equal efficiency. If gauze is not at hand the splints may be made of four-inch plaster bandages soaked in water and run back and forth on a table until the proper thickness has been attained.

It should be remembered in reducing an ordinary Pott's fracture that the deformity cannot be over-corrected.

An anesthetic is always advisable in reducing the deformity and in the application of a permanent dressing, unless some constitutional condition exists to act as a contraindication.

Following reduction a Röntgenogram should be taken to verify the position of the fragments.

The usual Pott's fracture can be reduced without difficulty as just described; occasionally complications exist such as the interposition of a fragment between the astragalus and the inner malleolus, which render reduction without operation impossible.

Operative Treatment.—The open method is indicated when good reduction cannot be accomplished by non-operative methods or when the fracture is compound from the first. If reduction has been attempted and failed, the X-ray will usually reveal the cause of the failure, if it has not already been learned through palpation and inspection. If, after complete inversion has been accomplished, the upper end of the fibular fragment remains displaced inward against the tibia and there is undue space between the external malleolus and astragalus, it will be advisable to make an incision over the fibular fracture, engage the fractured surfaces and secure the fibula in proper alignment. If internal fixation is found necessary to maintain reduction a Lane plate or wire may be used. If this inward displacement of the upper end of the lower fibular fragment is allowed to persist it means a widening of the mortise by outward displacement of the external malleolus, and a weak ankle will result. The interposition of a fragment between the inner malleolus and astragalus calls for removal of the obstructing material. This is best accomplished through a longitudinal incision below the inner malleolus. With the parts exposed the inner lateral ligament should be sutured before the incision is closed.

Operation is sometimes called for because of loss of function and painful joint following an imperfectly reduced Pott's fracture. When a patient presents himself for treatment under these circumstances the case should be carefully studied by the usual examination and the X-ray before an opinion or advice is given. The exact cause of the disturbed function should be accurately ascertained, and then, if surgical intervention offers relief, the parts should be opened. The usual causes of loss of function are traumatic flat-foot and backward displacement of the foot. Both of these conditions can, as a rule, be corrected by osteotomies or readjustment of the articular surfaces. The joint is best approached through two longitudinal incisions over the malleoli. Through the inner incision obstructing materials such as bone or periosteum may be removed from between the astragalus and inner malleolus. Through the outer incision the position of the external malleolus may be corrected, if in deformity, and an osteotomy of the fibula above the tibio-fibular ligaments may be performed if found necessary to bring the malleolus back into position. Obstructing fibrous tissue should be removed if present. The common method of correcting an old Pott's fracture deformity is by a double osteotomy of the tibia and fibula above the ankle. By this means the foot and ankle are brought back into proper alignment with the leg and both the outward and the backward displacements are corrected.

If the fracture is compound the lacerated edges should be excised, the wound and joint cavity thoroughly washed with a few gallons of physiological sterile salt solution and the parts closed. If infection follows in spite of this treatment the joint should be injected with Murphy's glycerine-formaline solution and the condition treated according to the principles laid down under the heading of "Compound Dislocations" on page 789. If the case is seen early and the treatment just mentioned followed it will usually be possible to obtain aseptic healing even though the fracture is badly compounded. Following operation splints should be applied as already described.

After-Treatment.—In the usual case of simple Pott's fracture the ankle should be maintained in adduction for a period of six weeks. No weight should be borne on the injured foot within two months of the time of the fracture. Massage of the leg, especially the calf muscles, is of advantage after the first week but it is best not to remove the splints early in the after-treatment lest recurrence of deformity take place.

There is a marked tendency to the development of flat-foot following Pott's fracture and it is due to incomplete reduction of the displacement or the too early use of the foot in bearing the weight of the body. Two months is a longer period than is usually advised before weight is borne on the foot, yet the author has found that if this length of time is allowed before the parts are subjected to strain, the patient does not develop flat-foot. The use of arch supports in the late after-treatment is an admission in itself that weight is being borne on the foot too soon. Passive motion of the foot, however, should be begun early but must be guarded lest outward strain be placed on the ankle. The foot should be carried through dorsal and plantar flexion but eversion must not be made. By means of massage, hot applications and passive motion the function of the joint should be well restored before the patient is allowed to bear his weight on the member in walking. Passive motion should be applied to the joints of the tarsus as well as to the ankle-joint proper, so that the full flexibility and usefulness of the foot may be restored.

Prognosis.—If proper reduction is accomplished and sufficient time is allowed for the solid repair of bone and ligament, in a healthy adult, the joint should be practically as useful and strong as before the injury. The older the patient, the longer the convalescence and the more incomplete the restoration of function. A certain amount of restriction of motion is common following this fracture and seems to be unavoidable. Cases in which accurate reduction has been accomplished and early passive motion instituted, show the greatest freedom of motion when recovery is complete. Extreme dorsal flexion is the motion most commonly restricted and the one least essential in the use of the foot. Traumatic flat-foot following Pott's fracture is a serious, crippling deformity and shows a tendency to grow worse when once established. Considerable relief may be had by the use of orthopedic appliances such as used in the treatment of flat-foot from other causes. Steel or felt arches to support the inner side of the foot and a building up of the inner side of the sole, may enable the patient to get about with more or less ease if the deformity is not too great.

Considerable improvement will usually take place during the first two or three months of active use and weight bearing.

Loss of lateral motion in the foot may be productive of lameness and constitute a serious disability. Lateral motion is not one of the normal actions of the ankle-joint but is accomplished by the articulations in the tarsus. It is evident therefore that this condition is not the result of the injury sustained by the tibio-fibular articulation but follows prolonged immobilization of the foot without the necessary early passive motion to the tarsus.

CHAPTER XLVII.

FRACTURES OF THE LOWER ENDS OF THE TIBIA AND FIBULA.

Surgical Anatomy.—The surgical anatomy of the lower ends of the tibia and fibula is similar to that already given under the heading of "Pott's fracture" on page 659.

Symptoms.—When both bones are fractured above the ankle, pain, loss of function, crepitus, abnormal mobility and swelling are usually present and well marked. The traumatic reaction is often less pronounced than that accompanying the usual fracture of the shaft and the mobility is, as a rule, not so completely flail-like. The line of fracture in the lower end of the tibia is quite variable and accordingly the deformity is not characteristic. The fracture may be transverse, spiral, comminuted or longitudinal. Longi-

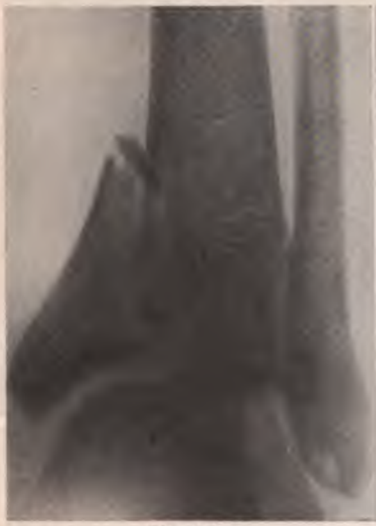


Fig. 749.

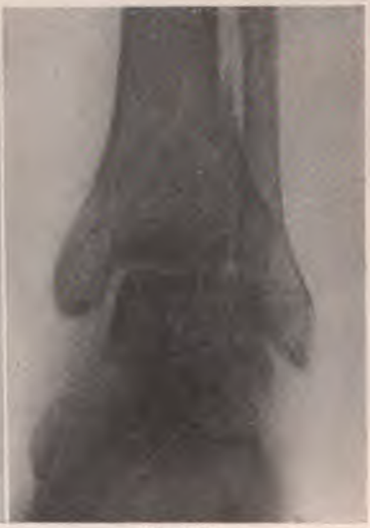


Fig. 750.

Fig. 749.—Splitting of lower end of tibia.
Fig. 750.—Splitting of lower end of tibia.

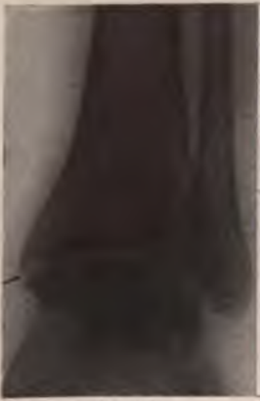


Fig. 751.

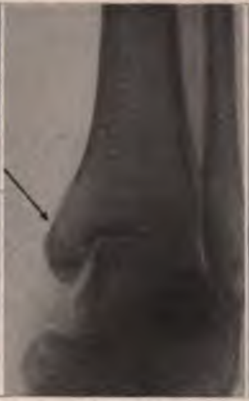


Fig. 752.

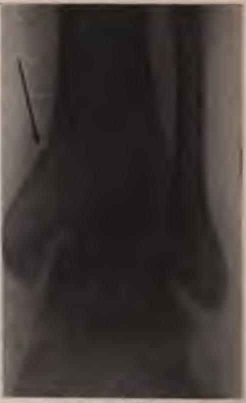


Fig. 753.

Fig. 751.—Fracture of tip of internal malleolus.
Fig. 752.—Fracture of internal malleolus at higher level.
Fig. 753.—Fracture of internal malleolus at still higher level.

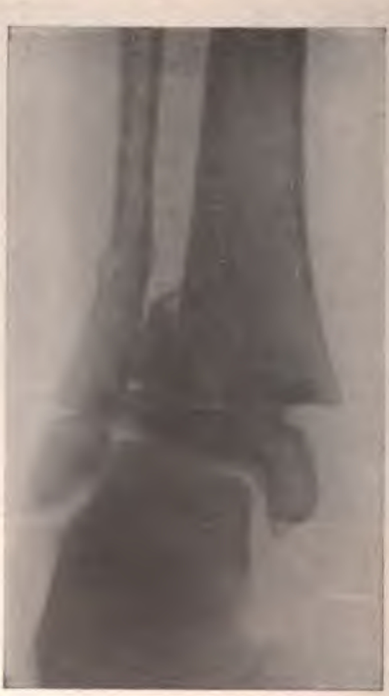


Fig. 754.—Epiphyseal separation of lower end of tibia complicated by fracture of tibial diaphysis. Also fracture of fibula. The result of violence similar to that producing Pott's fracture.

tudinal splitting of the lower end of the tibia entering the joint cavity is not at all uncommon and is usually accompanied by transverse thickening of the ankle. The line of fracture may extend from the inner surface of the bone into the joint cavity so that the inner malleolus is displaced inward or it may extend from the outer surface of the bone into the articulation and allow the fragment and lower end of the fibula to be displaced outward. Diastasis of the lower tibio-fibular articulation with separation of the lower ends of the bones of the leg is occasionally seen and has been classified as a complication of upward dislocation of the ankle when the astragalus is displaced upward between the ends of the bones. Supra-malleolar fracture of the tibia is usually accompanied by fracture of the lower end of the fibula. Fracture of the inner

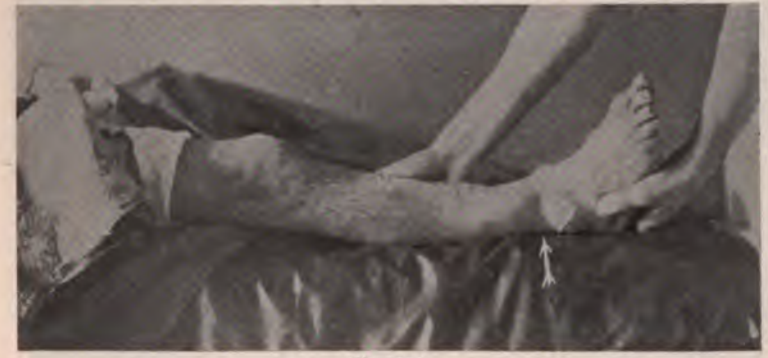


Fig. 755.

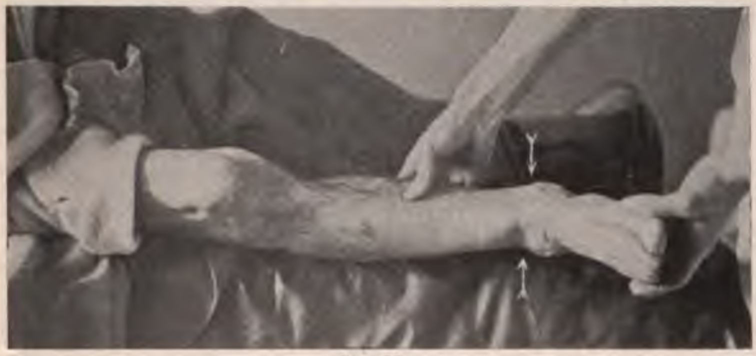


Fig. 756.

Figs. 755 and 756.—Fracture of both bones of the leg just above the ankle. Arrows indicate the levels of the two fractures.

malleolus usually occurs as a part of Pott's fracture, but even as an isolated injury it is not uncommon. Various types of fracture of the lower ends of the tibia and fibula occur as complications of dislocations of the ankle and of Pott's fracture, but will not be considered under this heading. It is not at all uncommon to see one of the tibial fragments projecting through the skin. The deformity may be pronounced and in cases resulting from direct violence the fragments may remain in the position in which they were driven at the time of the accident. Fracture of the lower end of the fibula is often attended by remarkably slight loss of function especially if the line of fracture is into the lower tibio-fibular articulation. The patient may be able to walk with such a fracture although use of the member entails pain.

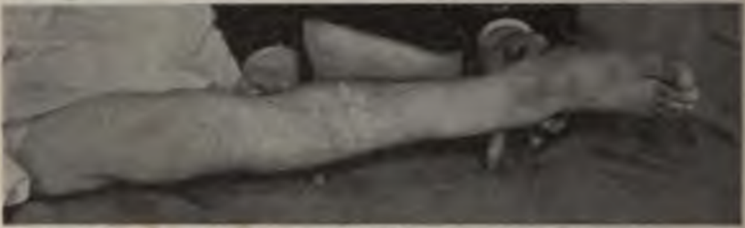


Fig. 757.

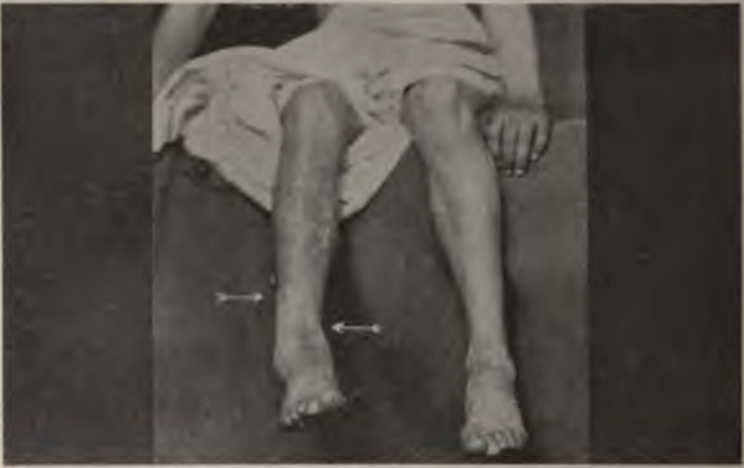


Fig. 758.

Figs. 757 and 758.—Supramalleolar fracture of both bones with inward displacement of the foot. Compare the two ankles. Arrows indicate the levels of the two fractures.

Diagnosis.—There should, as a rule, be little difficulty in recognizing fractures in this region but the details of the break are often difficult or impossible to recognize without the aid of the X-ray. Fracture of the fibula may be mistaken for a sprain unless the examination is carefully made. When the fracture is supramalleolar the two malleoli will remain in proper relation to each other but will move with the foot and not the leg. When the frac-

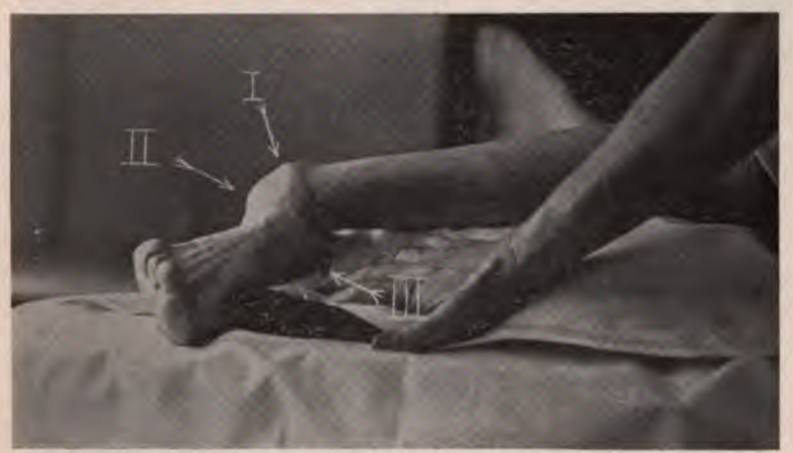


Fig. 759.

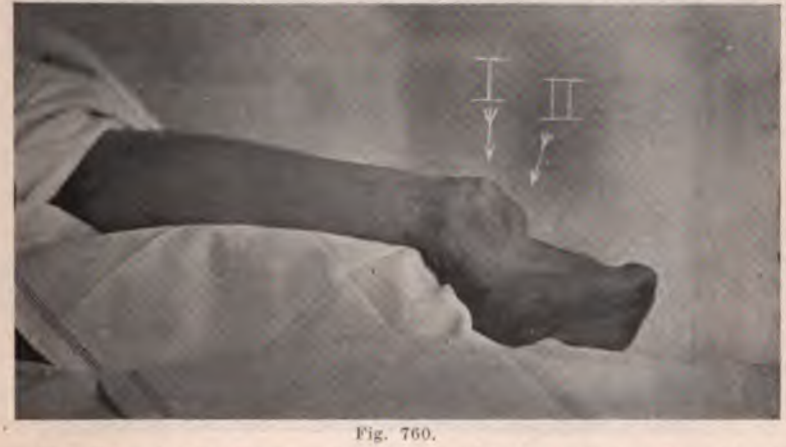


Fig. 760.

Figs. 759 and 760.—Fracture of both bones of the leg just above the ankle with pronounced inward displacement of the foot. The photographs were taken about twenty minutes following injury and show an unusual displacement. *I.* indicates the upper end of the lower fragment of the fibula. *II.* indicates the displaced external malleolus. *III.* indicates the internal malleolus. Injury the result of direct violence.

ture enters the joint cavity it will usually be possible to elicit abnormal mobility of one of the malleoli (the one detached). The symptoms in separation of the lower epiphyses are practically the same as in fractures of this region except for the crepitus which is cartilaginous and not bony. If the fracture in the fibula is above the lower tibio-fibular ligaments pressure in the middle of the shaft will produce pain at the seat of the fracture. If the fracture is through the ligaments or below them direct pressure at the site

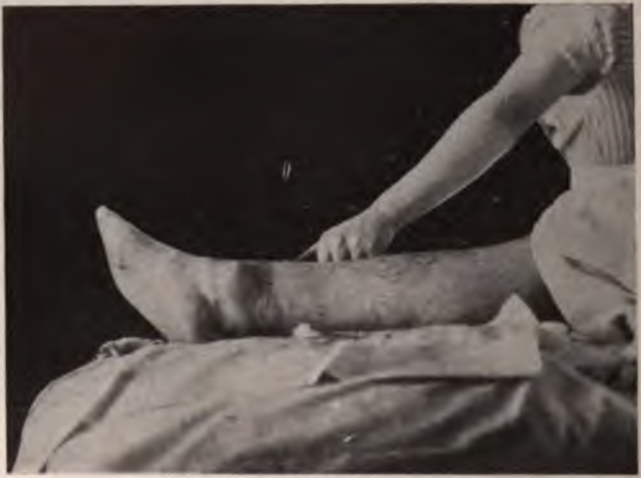


Fig. 761.

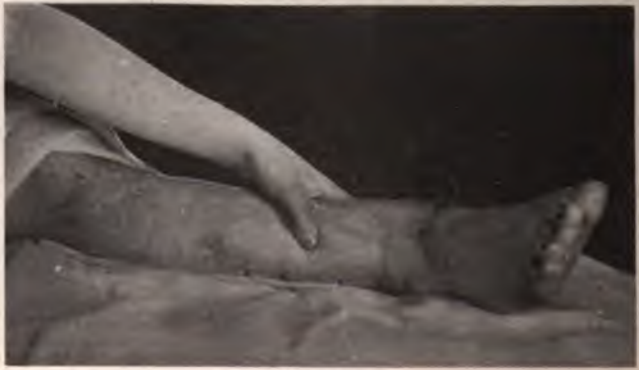


Fig. 762.

Figs. 761 and 762.—Splitting of the lower end of the tibia with broadening of the ankle. Both malleoli prominent. Type of case requiring operation to secure the best results.

of the lesion will be necessary to produce pain. When the fibula alone is fractured there is usually little loss of strength in the ankle.

Treatment.—In fracture of both bones above the ankle or in epiphyseal separations the indications in treatment are similar to those cases just described in which the fracture is at the usual site (the junction of the middle and lower thirds of the shafts). The necessity for temporary treatment is not as great in this region since the traumatic reaction is seldom as severe as in fracture of the shafts. It is best, however, to place the leg in a fracture-box or pillow splint for the first few days, until the amount of swelling to follow can be determined. During this time the ice cap locally and intermittently applied is of great value. A plaster stirrup as already described in ''Fractures of the Shaft'' will in most cases be found thoroughly efficient in maintaining reduction. A quick drying plaster should be used and the surgeon should hold the ankle in reduction, while the splint is setting. The best position for the ankle, in a given case, is the one in which the tendency to recurrence of deformity is least. It is preferable to fix the foot in a position of slight plantar flexion rather than at a right angle. The proper position for the foot, aside from the prevention of deformity, is one in which the flexor and extensor muscles are at an equal tension and balance each other. In instances in which the lower end of the tibia is split longitudinally it will often be

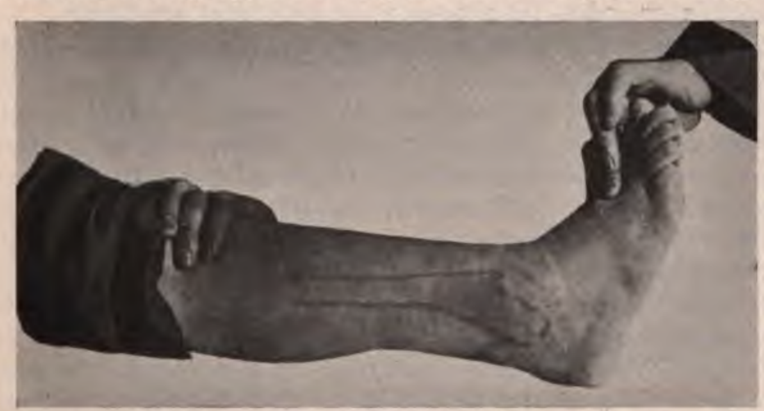


Fig. 763.—Old case of fracture of both bones of the leg above the malleoli. Patient presents himself for treatment because of inability to use limb. Pen outline on skin indicates palpation of fibula. This case is a good example of delayed restoration of function due to incomplete reduction of fragments.

necessary to force the fragments together, by lateral pressure, while the plaster is drying, in order that union may not take place with transverse thickening of the ankle and widening of the mortise. If the posterior portion of the articular surface of the tibia is broken off the foot should be more or less dorsally flexed to favor reduction and prevent recurrence. When a fragment is broken off of the articular surface anteriorly the foot should be immobilized in the opposite position for the same reasons. The foot should be covered with a layer or two of sheet cotton before the stirrup is applied. The bony prominences about the ankle are subcutaneous and if the splint is not properly padded undue pressure may produce sloughing of the skin. Fracture of the fibula alone does not require as solid immobilization as is the case in isolated fracture of the lower end of the tibia or when both bones are broken.

When an outward displacement of the external malleolus exists as a result of fracture of the fibula, whether the break is above, below or through the lower tibio-fibular ligaments, the deformity should be corrected and held in position by the dressing. Strong adduction of the ankle, as in the treatment of Pott's fracture, will usually correct this displacement if the internal malleolus is intact.

Operative Treatment.—Open treatment is not as frequently indicated in fractures of the lower ends of the tibia as it is when the shafts of these bones are broken. It is most commonly called for when there is a longitudinal splitting of the lower end of the tibia in which difficulty is experienced in approximating the fragments. Even a slight spreading of the malleoli means a widening of the mortise in which the trochlear surface of the astragalus rests and this condition, if not corrected, is followed by a protracted recovery if not permanent disability. If two longitudinal incisions are made, one on the inner and the other on the outer aspect of the lower part of the leg, the fragments can be replaced by direct manipulation and transverse holes drilled through the approximated fragments at the most advantageous points. Heavy wire is then threaded through these holes and the ends securely twisted to maintain proper reduction. In some instances passing wire around the fragments may be all that is required but this point can seldom be determined until the fragments are exposed. In supra-malleolar fractures open incision may be necessary to effect reduction but it is seldom necessary to employ internal fixation.

After-Treatment.—If the traumatic reaction is great the leg should be treated on a pillow splint or in the fracture-box during the first few days. The swelling is usually less than that seen when the fracture is higher, and it will seldom be necessary to wait more than four or five days before placing the leg in a permanent splint. As previously stated, the plaster stirrup is the most efficient form of permanent dressing in which to treat fractures in this region. Union may be expected in the healthy adult in six weeks but the callus is not sufficiently strong at this time to permit of weight bearing. Massage and gentle passive motion should be instituted at the end of the second week. During the eighth and ninth weeks weight bearing should be gradually increased until the patient is able to walk at the end of two and a half months. The time should be prolonged in cases in which the fracture involves the articular surfaces and when passive motion is employed due regard should be had for the tendency to displacement, if such exists. It is best for the patient to walk with a cane for some time following the removal of all dressings. Persistent swelling of the ankle should be met with massage and hot applications and, if pronounced, great relief may be had by the use of an elastic stocking during the day. Isolated fracture of the fibula without displacement may, as a rule, begin weight bearing at the end of three or four weeks.

Prognosis.—The more accurate the reduction the more complete and prompt is recovery. Some limitation of motion in the ankle, especially dorsal flexion, is common, following fractures in this region, particularly so when the line of fracture involves the articular surface. Fractures of the fibula alone are usually followed by complete restoration of function. The prognosis in other respects is similar to that already given in "Fractures of the Shafts of the Bones of the Leg," page 657.

CHAPTER XLVIII.

DISLOCATIONS OF THE ANKLE.

Surgical Anatomy.—The bones entering into the formation of the ankle-joint and the ligaments holding these bones in apposition, have already been mentioned in the surgical anatomy of "Pott's fracture," on page 659. The manner in which the malleoli are placed on either side of the body of the astragalus explains the frequency with which fracture complicates dislocations of this articulation. Nearly all the luxations of the ankle are accompanied by fracture of either the tibia, fibula or astragalus. One or both malleoli may be broken off and displaced with the foot.

The bones of the ankle are not deeply situated and it is not uncommon to see compound luxations of the ankle. When severe and direct violence is applied to the ankle, the foot may be torn away from the tibia and fibula and displaced in any direction. The greater the violence producing the injury the greater the probability of the condition being compound and complicated by fracture of the malleoli or astragalus. In severe cases the bones of the foot may be entirely torn from the lower end of the leg with only the soft tissues connecting the two, and a large rent in the skin. In such instances the character of the deformity is not typical of any of the forms of ankle luxation to be described.

The typical luxations of the ankle in their order of frequency are: outward, inward, backward, forward, and upward. It should be remembered, however, that a given luxation may present a displacement resembling two forms of dislocation. Thus the foot may be displaced forward and inward so that the deformity shows some of the characteristics of both the forward and inward types of dislocation. In many of these luxations (especially the lateral types) there may be a rotary element present in which the foot is turned either inward or outward on a more or less vertical axis. This form of displacement has been described as a separate form of luxation, and may occur as such, but is almost always secondary to one of the other dislocations just mentioned.

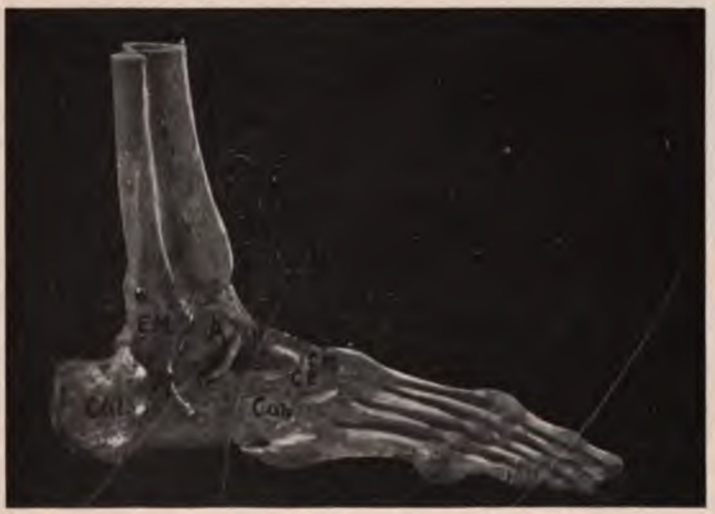


Fig. 764.—View of ligaments of foot from fibular side. *E.M.*, External malleolus; *A.*, Astragalus; *N.*, Navicular; *C.M.*, Middle cuneiform; *C.E.*, External cuneiform; *Cal.*, Calcaneum; *Cub.*, Cuboid.

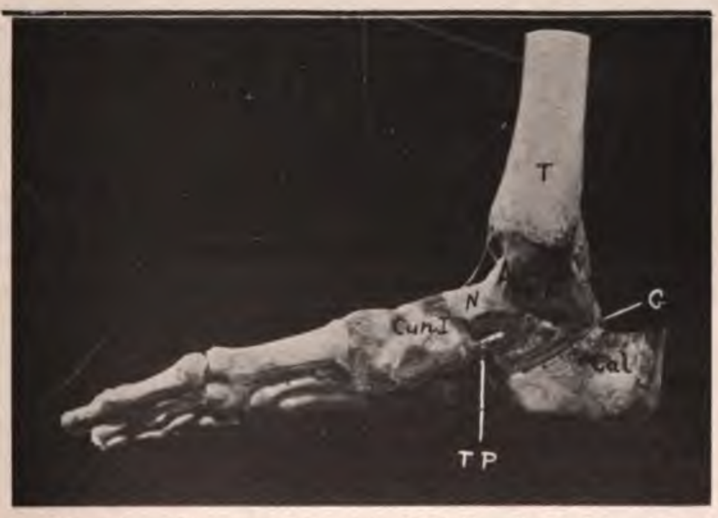


Fig. 765.—View of ligaments of foot from tibial side. *Cun.I.*, Internal Cuneiform; *N.*, Navicular; *A.*, Astragalus; *T.*, Tibia; *Cal.*, Calcaneum; *T.P.*, Tendon of tibialis posticus; *G.*, Groove for the passage of the tendon of the tibialis posticus.

In *outward luxations* the lesions are somewhat variable. The less severe forms of this dislocation are the same as Pott's fracture, which has already been described. When the force which produces Pott's fracture continues to act, the lower tibio-fibular ligaments are either ruptured, or tear away their tibial attachment, including a fragment of bone, and the astragalus continues in its outward course. If the displacement is great enough to allow the trochlear surface to clear the tibial articular surface, the astragalus will be displaced upward as well as outward and is described as one of the upward luxations of the ankle (Dupuytren's dislocation). The more pronounced the lateral displacement of the ankle (until it clears the tibia) the greater the tendency of the astragalus to rotate on a more or less horizontal antero-posterior axis. When this rotation occurs the foot corresponds to the position assumed by the astragalus. The outer side of the foot is raised and the sole looks downward and outward. The surgical anatomy of this fracture luxation is the same as Pott's fracture (see page 659).

In *inward luxations* of the ankle ("inverted" or "reversed" Pott's fracture) the fibula is usually fractured at the level of the joint and the inner malleolus is broken off at its base. The line of fracture in the tibia is usually oblique, extending upward and inward from the junction of the horizontal and vertical portions of the lower tibial articular surface. The usual position of the fracture is well illustrated in Fig. 753. The astragalus commonly shows more or less rotation in a direction opposite to that usually seen in Pott's fracture. The foot is displaced inward according to the degree of causative violence. Inward rotation of the foot is particularly common in this form of luxation.

Backward luxations are extremely rare and almost invariably accompanied by fracture. They may result from extreme plantar flexion of the foot or from a force which drives the foot backward when the leg is fixed. The reverse mechanism may obtain in which the lower end of the leg is driven forward while the foot is fixed. When this type of luxation is the result of extreme plantar flexion the posterior margin of the tibia is almost invariably broken off. It is common for one or both of the malleoli to be broken off and displaced backward with the foot. The lower end of the tibia rests on the scaphoid and cuneiform bones while the astragalus is displaced backward. The ligaments of the joint suffer extensive laceration. If one malleolus and its corresponding lateral ligament remain intact the backward displacement will be accompanied by more or less of a rotary deformity with the sound malleolus as the center of the arc described.

Forward luxations are extremely rare and almost invariably accompanied by fracture of the malleoli or the anterior edge of the tibia. This type of dislocation of the ankle is produced by a force which drives the lower end of the leg backward while the foot is fixed, or the same result may follow a blow on the heel which drives the foot forward while the leg is fixed. Extreme dorsal flexion, alone or combined with an antero-posterior force, may be responsible for the luxation. When caused by flexion the anterior edge of the lower end of the tibia is almost always broken off. The reported cases of this luxation are very few, being less than fifteen in all and have usually been accompanied by fracture. Most of the uncomplicated cases were reported before the X-ray came into use and some writers question the occurrence of this luxation unaccompanied by fracture. The case shown in Fig. 768, however, is a pure luxation, as demonstrated by the X-ray plate which was taken following reduction and which showed no fracture.

Upward luxations of the ankle are extremely rare. Two forms are described. The first is simply an exaggerated Pott's fracture with diastasis of the lower tibio-fibular articulation and an upward displacement of the astragalus between the lower ends of the tibia and fibula. This luxation has already been described with outward dislocations of the ankle and is known as Dupuytren's luxation. The second form of upward dislocation is one in which the astragalus is displaced upward between the lower ends of the tibia and fibula following a diastasis of the tibio-fibular joint, without the usual complicating fracture of the fibula.

Symptoms.—In all forms of ankle luxations the pain, tenderness, loss of function and swelling are usually pronounced. Ecchymosis often develops within twelve to twenty-four hours and is much more constant if the condition is accompanied by fracture. The deformity varies with the type of luxation.

In *outward luxations* the appearance of the ankle is usually typical of Pott's fracture and the exaggerations of this deformity just described.

In *inward luxations* of the ankle, the foot is usually markedly inverted with more or less adduction. The inner side of the foot is higher than normal while the outer edge of the sole is depressed.

The deformity is symmetrically opposite to that seen in Pott's fracture. When rotary deformity accompanies the condition it is usually inward, and may be as much as ninety degrees, so the toes point directly toward the opposite foot.

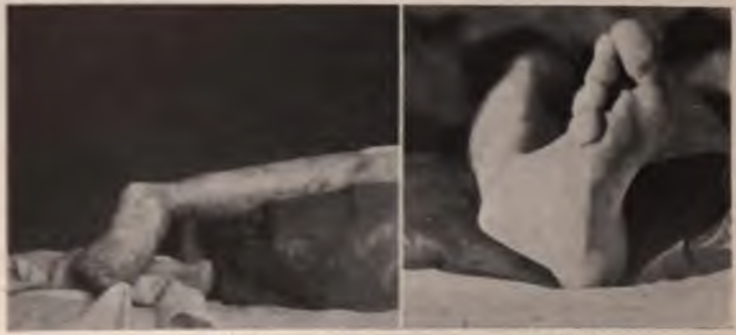


Fig. 766. Fig. 767.

Figs. 766 and 767.—Inward fracture-luxation of the ankle a few minutes following the injury. Inner malleolus broken off and displaced with the foot. The external malleolus remains intact. Note the prominence of the external malleolus and the way the skin is stretched between it and the foot. Reduction accomplished without difficulty.

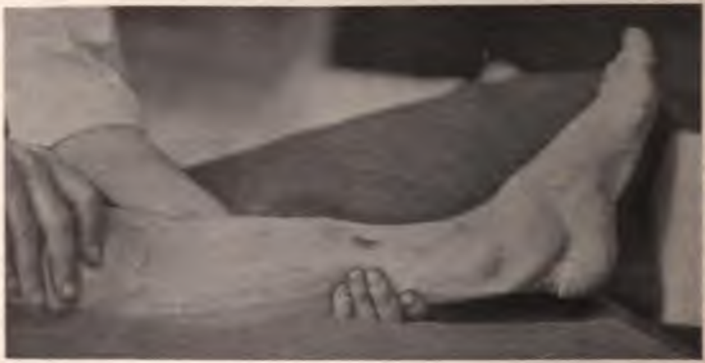


Fig. 768.—Anterior dislocation of ankle. The entire tarsus is displaced forward at the tibio-astragaloid articulation. Note the prominence of the internal malleolus in its backward displacement. Injury sustained in automobile accident. Dislocation caused by blow on posterior aspect of heel. Trauma of vulnerant body was sufficiently great to penetrate counter of shoe, without, however, injuring skin on heel. Reduction easily accomplished by pressure in bend of ankle accompanied by traction on the foot. Picture taken about two hours following accident. X-ray plate taken following reduction showed no fracture.

In *backward dislocations* the dorsum of the foot is shorter than normal and the heel is unduly prominent. The foot is usually held in a position of more or less pronounced plantar flexion as a result of the increased leverage of the muscles attached to the tendo Achillis. A transverse ridge is felt anteriorly, in the bend of the ankle, and the extensor tendons may be palpated passing across it from the leg to the foot. If the malleoli are not fractured they will be found displaced forward with the leg.

In *forward luxations* the appearance of the foot and ankle is the reverse of that just described. The dorsum of the foot is lengthened and the heel shortened. The malleoli are both displaced backward unless broken off. The trochlear surface of the astragalus can, as a rule, be felt in the bend of the ankle, and when the usual fracture is present it may be possible to palpate the detached tibial fragment.

In *upward luxations* accompanied by fracture of the fibula the clinical picture is that of an exaggerated Pott's fracture. Abnormal lateral mobility, broadening of the malleoli, more or less eversion and crepitus are usually present on examination. The condition is often compound. When upward luxation exists without fracture of the fibula abnormal lateral mobility may be absent. The malleoli are lowered (nearer the sole of the foot) and widely separated. The leg above the ankle is broader than normal.

Diagnosis.—With a knowledge of the anatomy of the parts it is not difficult to recognize the different types of luxation which occur at the ankle. The presence of complicating fracture, however, is often not easy to determine without the aid of the X-ray. If the case is not seen until some hours have elapsed following the injury the swelling may be so intense that palpation is quite difficult. The disturbance in the alignment of the foot and leg, as viewed from the side and antero-posteriorly, should be recognized by inspection even if the swelling is pronounced. Motion of the foot will usually reveal the nature of the injury. An X-ray examination of these conditions cannot be considered complete unless two plates at right angles to each other are made.

Treatment.—The nature of the injury should be appreciated by the surgeon before an attempt at reduction is made. There is usually little difficulty in returning the articular surfaces to their normal relations but when fracture complicates the condition, as it frequently does, some trouble may be experienced in maintaining reduction. A short plaster stirrup, as already described in the treatment of fractures of the tibia and fibula, is the most satisfactory method of treating these luxations but the application of this dressing should be delayed until the swelling (if pronounced) has subsided. During this time the ankle may be treated in the pillow splint or fracture-box with the foot elevated and the ice cap applied. If no fracture exists the most comfortable position for the foot is at an angle of about 100 degrees with the leg. In other words the foot should be immobilized in a position a little more than a right angle. If the anterior edge of the tibia has been fractured the foot should be fixed in plantar flexion, if the posterior edge is broken off it should be placed in dorsal flexion. In fracture of the malleoli there is usually little tendency to the recurrence of deformity if good reduction has been accomplished. In the treatment of Pott's fracture the foot is inverted as far as possible and there is no danger of overcorrecting the deformity, but in inward luxations of the ankle the reverse is not true. The deformity can be overcorrected and if the foot is put up in extreme eversion the result will be recovery with pronounced deformity. The reasons for this are apparent if we note the lines of fracture in an inward luxation as compared with a Pott's fracture. In an inward luxation the foot should be brought back into alignment with the bones of the leg and fixed with a plaster stirrup.

Operative Treatment.—Operative treatment is usually not called for except in compound luxations and in instances in which complicating fractures cannot be satisfactorily reduced by non-operative methods. The fragment of a fractured malleolus may become displaced and wedged between the astragalus and end of the tibia, requiring removal before proper reduction can be effected. If one of the malleoli or a portion of the lower end of the tibia remains displaced, in spite of attempts at reduction, it may be advisable to fix it in position through an open incision.

Compound dislocations of the ankle should be treated along the lines laid down in the treatment of "Compound Luxations" on page 789. The cavity of the articulation should be irrigated with a few gallons of sterile salt solution, devitalized tissue trimmed away and the wound closed. Fragments should not be wired at this time. If internal fixation is found necessary it should be performed at a later date after the primary wound has healed. If severe infection develops amputation may be necessary especially if the patient is old and feeble. Amputation, however, is rarely called for, even in compound cases, if proper surgical measures are carried out.

After-Treatment.—The care of these cases following reduction varies greatly with the complications. In simple dislocations of the ankle without fracture, ligamentous union will be firm at the end of about three weeks. Function should be resumed gradually. Gentle passive motion should be begun at the end of ten days. When the condition is complicated by fracture of the lower ends of either the tibia or fibula the after-treatment will be practically the same as that already given for "Pott's fracture" (page 673) and in "Fracture of the Lower Ends of the Tibia and Fibula."

Prognosis.—In simple luxations the prognosis is good but when fracture complicates the dislocation (as it almost invariably does) the outlook varies with the nature of the break. The prognosis is essentially that of the complicating fracture and may be considered the same as set down under "Fractures of the Lower Ends of the Tibia and Fibula," page 683, and under "Pott's Fracture," page 673.

CHAPTER XLIX.

FRACTURES AND DISLOCATIONS OF THE ASTRAGALUS.

When the astragalus is luxated from the navicular or the calcaneum, but remains in its normal relation with the bones of the leg, the condition comes under the heading of Subastragalar and Medio-tarsal Dislocations (pages 699 and 709). When the astragalus is dislocated from the tibia and fibula, but remains attached to the tarsal bones, the condition is known as a dislocation of the ankle. Complete luxations, therefore, are the only displacements of this bone considered under this heading. These may be in any direction but are most commonly forward, or forward and outward.

Surgical Anatomy.—The astragalus is composed of soft cancellous bone covered by a layer of compact tissue. The greater part of the surface of the bone is taken up by the articular surfaces which enter into the formation of the calcaneo-astragalar, astragalo-navicular and tibio-tarsal joints. Above, it articulates with the tibia and laterally the two malleoli extend downward and em-

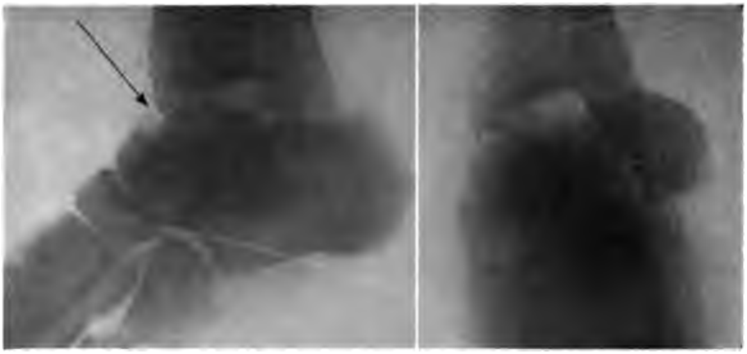


Fig. 769. Fig. 770.

Figs. 769 and 770. Lateral and antero-posterior views of a fracture-luxation of the astragalus. Fracture passes through neck of bone, the anterior fragment being displaced laterally.

brace it, thus forming the firm compact mortise of the tibio-astragalar articulation which allows of motion in only one plane. Below, the astragalus presents two articular surfaces which enter into the formation of the calcaneo-astragalar joint. These two facets are separated by a deep groove for the attachment of the heavy interosseous ligament which holds the calcaneum and astragalus together. The anterior surface of the astragalus (the head) projects forward, inward and downward and articulates with the navicular.

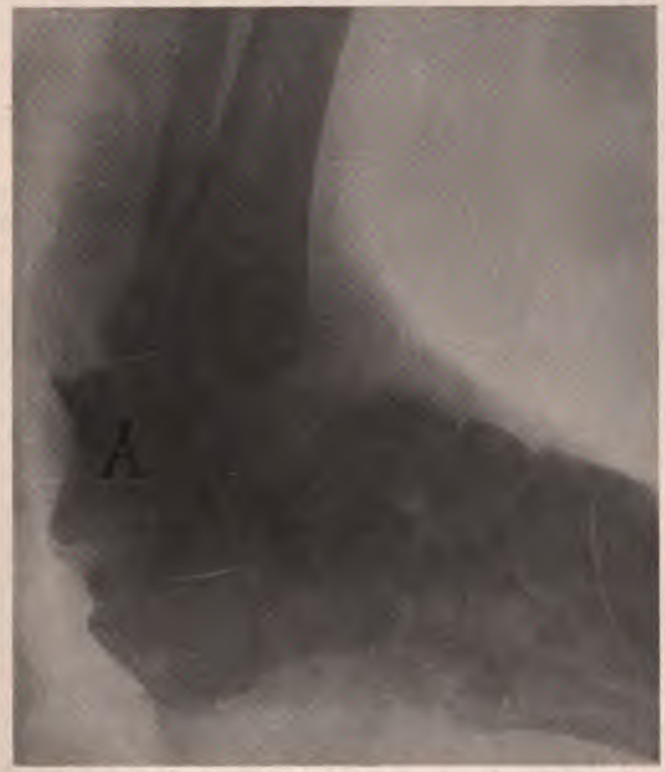


Fig. 771.—Antero-posterior view of outward luxation of astragalus. The bone is rotated on an antero-posterior axis as well as being displaced laterally.

The astragalus is held in position by the conformation of the bones surrounding it and the heavy ligaments which bind it to the tibia, fibula, calcaneum and navicular. There are no muscular attachments on this bone.

In falls on the foot the astragalus may be crushed between the tibia and calcaneum and is not infrequently associated with fracture of the latter bone. This type of violence, however, is much more likely to produce fracture of the shafts of the bones of the leg or fracture of the os calcis.

In fractures of the body of the astragalus the nature of the break is not constant; it may be transverse, longitudinal, or stellate, or the entire body may be extensively crushed and comminuted, with a decrease in the distance between the calcaneum and bones of the leg.

Fracture of the neck of the astragalus is the most common break occurring in this bone and usually results from extreme dorsal flexion of the foot. Fractures of the neck of the bone are usually transverse and the head is seldom much displaced. Lateral luxations may occur with fracture of the malleoli, and backward dislocation of the body of the bone accompanied by fracture of the neck is a condition which occurs, but is extremely rare. The soft tissues surrounding the ankle are scant, and in the usual forward, or forward and outward luxation there is scarcely room within the skin to accommodate the bulk of the displaced bone. Accordingly luxations of the astragalus are often compound. In simple cases the skin covering the displaced bone is rendered so tense that sloughing is likely to follow if the displacement is allowed to remain unreduced. The ligamentous damage accompanying luxations of the astragalus is usually extensive. The displacement of this bone throws the foot out of alignment, and the deformity will depend largely on the position occupied by the astragalus. The displaced bone may be rotated in various directions depending largely on the trauma which produced the luxation. Fracture and dislocation may both be present in the same case. In such instances there is usually a fracture of the neck with luxation of either the head or body.

Symptoms.—The symptoms accompanying fractures and dislocations of the astragalus vary greatly with the nature and degree of the injury. Fractures of this bone, especially of the body, have frequently been mistaken for sprains of the ankle and treated accordingly. In fractures of the body, pain, swelling and disability are pronounced. Motion of the ankle and attempts at weight bearing greatly increase the suffering. Crepitus may, or may not, be present. It is usually best elicited by palpation in the bend of the ankle while the foot is being passively flexed and extended. Fracture of the neck of the astragalus is usually attended by symptoms a little more pronounced than is the case in fractures of the body. Pain, loss of function, swelling and local tenderness are generally severe and crepitus is, as a rule, easily elicited by lateral motion of the foot. Deformity, if present at all, is usually very slight in either fracture of the body or neck.

In luxations of the bone loss of function, pain, swelling and local tenderness are equally as pronounced as in fracture, and the deformity is usually extreme. In any of the forward displacements the bone may be felt as a prominent mass in the bend of the ankle, the foot is more or less depressed and the malleoli are lowered. When the astragalus is displaced forward and outward the foot will be inverted. When the bone is luxated forward and inward the foot will be everted. In backward luxations of the bone (practically always associated with fracture of the neck) the body may be felt between the lower end of the tibia and the tendo Achillis, and an abnormal hollow will be noted anteriorly, below the lower end of the tibia. Lateral luxations are associated with fractures of one or both malleoli, are usually incomplete and resemble lateral dislocations of the ankle.

Diagnosis.—The diagnosis of these different lesions is based on the symptoms just given. Fractures of the astragalus are often difficult to determine unless crepitus can be elicited and even then the surgeon's appreciation of the condition is likely to be vague if the case is not examined with the X-ray. The deformity in luxations is usually sufficiently pronounced to permit of recognition of the condition. The association of fractures of the different bones of this region is so frequent that the X-ray should be employed whenever available. By its use complicating lesions are often shown to exist, which would otherwise be overlooked.

Treatment.—The traumatic reaction is often severe during the first few days or week in fractures of this bone and during this time it is advisable to treat the leg in the pillow splint, in the elevated position and with the intermittent use of the ice cap. When the swelling has subsided the foot and ankle may be fixed in a short plaster stirrup after the parts have been properly covered with sheet cotton to provide the necessary padding. The best reduction is usually had in a position of slight plantar flexion, which position is preferable in most cases to the academic "right angle,'' so insistently and uselessly demanded in most text-books. If the condition is accompanied by other fractures in the foot a more complete fixation may be required, and is had by means of a short posterior plaster splint. This splint is applied before the stirrup and extends down the leg and under the foot to a point just beyond the toes. It is the same as used in fractures of the metatarsals.

In dislocations of the astragalus reduction should be effected at the earliest possible moment, unless the condition is compound. The necessary manipulations will depend entirely upon the position occupied by the displaced bone. The object is to return the trochlear surface of the astragalus to its proper relation in the mortise formed by the tibia and fibula. This may be a difficult matter especially if rotation of the bone has occurred. The fact that no tendons are inserted into the astragalus increases the difficulty of reduction.

In forward displacements of the bone, direct backward pressure on the prominent trochlear surface will usually effect reduction. Plantar flexion before the bone is ''started,'' and dorsal flexion in the latter part of the manipulation may aid materially in reduction.

In the forward and outward type of luxation similar maneuvers are employed. The common outward rotation of the bone is often difficult to correct, and until it is, it will usually be impossible to effect reposition. Strong traction on the foot and sometimes an accentuation of the inversion will render the direct pressure more efficient.

In inward and forward luxations the opposite manipulations are necessary to return the bone to its normal position.

In backward luxations with the usual fracture of the neck, strong traction with direct forward pressure on either side of the ankle in front of the tendo Achillis, will usually be sufficient to accomplish reduction. Plantar flexion of the foot while traction is being made, will increase the distance between the calcaneum and the tibio-fibular mortise posteriorly and may thus facilitate reduction. If reduction cannot be accomplished by manipulation, open incision under proper surgical surroundings should be resorted to at once. This is particularly true of any of the anterior luxations, since the pressure exerted by the displaced bone may produce sloughing of the integument and render the condition compound. The fact that the trochlear surface is slightly broader anteriorly accounts for the frequency of complicating fractures of the malleoli in backward luxations. When either of the malleoli are broken they deserve special consideration in the treatment (see "Pott's Fracture," page 668, and "Dislocations of the Ankle," page 689. The treatment of lateral dislocations with fracture of the malleoli is similar to that already given for lateral luxations of the ankle. When either fracture or luxation of the astragalus is compound, immediate operative intervention is demanded.

Operative Treatment.—Operation is seldom indicated in the treatment of simple, uncomplicated fractures of the astragalus. It is called for in compound cases and in instances in which luxations of the bone cannot be immediately corrected by manipulation. In compound cases no attempt at reduction should be made until the patient is in the operating room. The skin should be painted with a five percent tincture of iodine, lacerated and devitalized tissue should be trimmed away from the margin of the wound and the cavity irrigated with a few gallons of sterile salt solution. The surgeon then determines what the individual needs of the case may be. Fractures usually require nothing in the way of reduction, and internal fixation of the fragments is not feasible.

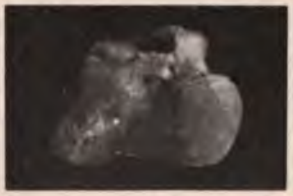


Fig. 772.—Deformed astragalus removed to restore function. Old fracture with union in deformity.

In luxations the bone is to be returned to its normal position by direct manipulation while traction, flexion, extension or other needed maneuvers of the foot are carried out. Care should be exercised to avoid injury to the articular surfaces while grasping the bone with forceps. The best place to grasp the astragalus and one in which the teeth of the forceps will do no damage, is at the neck.

The wound is then closed with interrupted sutures. If difficulty is experienced in bringing the edges of the wound together, after the devitalized tissue has been removed, it may be necessary to perform some plastic, skin-sliding operation. It is imperative that the wound be closed at this time, even at the expense of leaving some adjoining area denuded. If suppuration occurs in spite of this treatment (and it rarely does) drainage will be necessary.

Excision of the bone in difficult cases was the usual treatment a few years ago but at the present time there seems to be no excuse for this procedure, except in the most extreme cases. In old unreduced luxations, and in recent cases in which necrosis develops in the astragalus it may be necessary to excise the bone, either entirely or in part. In instances in which ankylosis of the tibio-tarsal articulation follows suppuration surprisingly good function may be restored by a spontaneous increase in the range of motion in the medio-tarsal articulation.

After-Treatment.—In fractures of the astragalus due time should be allowed for proper union of the fragments. It should be remembered in this respect that the strain entailed in ordinary walking is considerable, and unless the callus is well ossified and solid, deformity may follow. The foot should be protected from weight bearing until two months or more have elapsed from the time of the injury and even then function should be only gradually resumed. Massage and early passive motion, however, are essential in preventing joint adhesions, and if properly employed, subject the parts to very slight strain.

The resumption of function may be begun at the end of four or five weeks in simple luxations. Complicating fractures of adjoining bones modify the after-treatment according to the nature of the lesion.

Prognosis.—In [illegible] of the astragalus, with proper and prompt [illegible] look for practically complete restoration of [illegible] fractures depends on the severity of the [illegible] rally as favorable as is the case in [illegible] is slower and ultimately some restriction [illegible] Simple transverse fracture of the neck is [illegible] than is usual with fractures of [illegible]

In [illegible] been allowed to go untreated the [illegible] are usually pronounced. Surprisingly [illegible], frequently follows complete removal of [illegible] that the wound be closed at this time, even at the expense of leaving some adjoining area denuded. If suppuration occurs in spite of this treatment (and it rarely does) drainage will be necessary.

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The resumption of function may be begun at the end of four or five weeks in simple luxations. Complicating fractures of adjoining bones modify the after-treatment according to the nature of the lesion.

Prognosis.—In simple luxations of the astragalus, with proper and prompt reduction, we may look for practically complete restoration of function. The outlook in fractures depends on the severity of the lesion and is not generally as favorable as is the case in simple dislocations. Recovery is slower and ultimately some restriction in motion may exist. Simple transverse fracture of the neck is usually followed by better results than is usual with fractures of the body.

In instances in which luxations have been allowed to go untreated the loss of function and deformity are usually pronounced. Surprisingly good function, however, frequently follows complete removal of the bone.

CHAPTER L.

SUBASTRAGALAR LUXATIONS.

Surgical Anatomy.—The astragalus rests upon, and articulates with, the calcaneum by two facets which are divided by a deep groove for the attachment of the heavy interosseous ligament. The calcaneum and astragalus are directly bound together by the internal, external and posterior calcaneo-astragaloid ligaments and by the interosseous ligament. Both the internal and external lateral ligaments of the ankle-joint are attached below to the calcaneum as well as the astragalus, and in subastragalar luxations either of the malleoli may be broken by the direct pull of these ligaments. The relatively low position of the external malleolus exposes it to fracture by direct pressure of the calcaneum when the luxation is outward. The only ligament passing between the astragalus and navicular is the superior astragalo-navicular which is thin and weak. The place of the lower ligament is taken by the calcaneo-navicular ligament. This ligament, by binding the calcaneum to the navicular, maintains the head of the astragalus in apposition with the navicular.

In subastragalar dislocations the calcaneum may be displaced inward, outward, backward or forward. The astragalus remains in position in the tibio-fibular mortise while the bones of the tarsus below it are displaced as a whole. The most common luxation is lateral, oblique, incomplete and often compound. The displacement is usually more complete in the posterior subastragalar joint than in the anterior. The head of the astragalus is, as a rule, completely separated from the navicular. There is often slight backward displacement accompanying either the inward or outward luxation. Forward luxations are extremely rare, resembling in this respect forward dislocations of the ankle-joint. The articulation between the head of the astragalus and the navicular is almost invariably broken up in subastragalar luxations regardless of the direction in which the foot is displaced.

The usual subastragalar luxation is the result of forcible inversion or eversion of the foot and not infrequently occurs in falls on the foot. This type of violence is much more likely to produce fracture-luxations of the ankle than dislocations of the subastragalar articulation. Fracture of the neck of the astragalus is a complication which has been recorded in a number of cases.

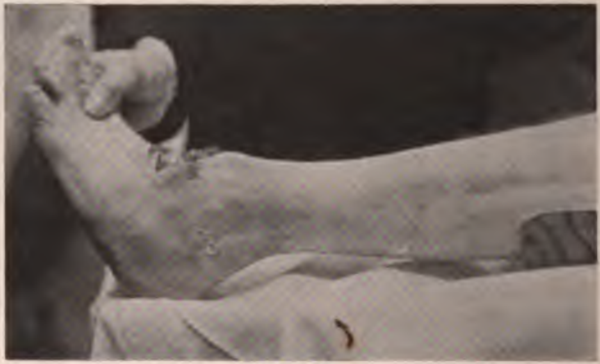


Fig. 773.

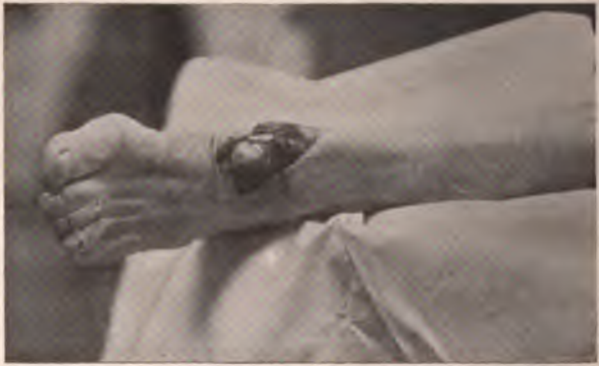


Fig. 774.

Figs. 773 and 774.—Case of backward dislocation of the calcaneum and scaphoid on the astragalus. (Backward subastragalar luxation.) The calcaneo-astragalar joint has been dislocated and the articulation between the astragalus and navicular has been entirely broken up. The head of the astragalus is seen presenting in the wound with the tendon of the tibialis anticus lying internal to it. Result of falling down an elevator shaft. The foot below the astragalus is displaced backward. Note the prominence of the heel.

Symptoms.—In outward luxations the sole of the foot looks downward and outward and the whole foot is displaced laterally. The inner malleolus is abnormally prominent and the head of the astragalus may be palpated. The malleoli are in normal relation with each other and with the astragalus, which is not displaced with the foot. The external malleolus is less prominent than normal. If backward displacement of the foot exists, as well as lateral, there will be an undue prominence of the heel and a corresponding shortening of the dorsum of the foot.

In inward luxations the reverse deformity is seen. The sole of the foot looks downward and inward. The inner border is raised and more concave than normal. The external malleolus is unduly prominent. The head of the astragalus may be palpated and the scaphoid may be felt near the inner malleolus. The whole foot is displaced inward. Antero-posterior luxations resemble dislocations of the ankle in the same plane. The fact that the astragalus, however, remains in its normal relation with the bones of the leg causes the deformity to be at an obviously lower level than that seen in dislocations of the ankle.

In posterior luxations the dorsum of the foot is shortened and the heel abnormally prominent. The head of the astragalus projects into the bend of the ankle and may be readily recognized in this position. The condition may be compound as shown in Figs. 773 and 774.

Anterior luxations are extremely rare. The heel is shortened and the dorsum of the foot lengthened. Palpation reveals the astragalus in its tibio-fibular mortise.

Diagnosis.—The diagnosis of these luxations is based on the characteristic deformities just described. If the swelling is intense it may be difficult to recognize the exact nature of the deformity. An X-ray is of the greatest value in ascertaining the details of the injury.

Treatment.—There is seldom much difficulty in reducing the deformity. In the lateral luxations the surgeon secures a firm grasp of the heel with one hand and the dorsum of the foot with the other, and by strong traction the foot is brought back into position. Counter-traction will usually be needed and should be made by an assistant, above the ankle. In backward luxations forward traction should be exerted on the heel while the leg is fixed. The reverse manipulation is performed to correct anterior luxations. The parts should be fixed in a plaster cast extending from the middle of the leg to the toes and cut open before the plaster has dried.

Operative Treatment.—If reduction cannot be performed by manipulation, open incision with direct reposition of the displaced bones should be performed.

After-Treatment.—Firm union of the lacerated ligaments will be present at the end of two and a half to three weeks. Passive motion should be begun at the end of ten days but the patient should not be allowed to bear his weight on the foot inside of three weeks from the time of the accident.

Prognosis.—The loss of function following this accident is very trivial if proper reduction of the displacement has been accomplished following the injury. Like dislocations in other joints, the too early use of the parts is likely to be followed by recurrence of the luxation which may even become habitual.

CHAPTER LI.

FRACTURES AND DISLOCATIONS OF THE CALCANEUM.

Surgical Anatomy.—Fracture of the os calcis is a fairly common accident but isolated luxations of this bone are extremely rare. The internal structure of the bone is cancellated while the surface is composed, for the most part, of a thin layer of compact tissue. The surface layer is heavier on the external, lateral surface of the bone than elsewhere. The os calcis articulates above with the astragalus by two facets, which are divided by a deep groove for the attachment of the heavy interosseous ligament binding these two bones together. The anterior extremity of the calcaneum articulates with the cuboid which in turn supports the fourth and fifth metatarsal bones. The os calcis is connected by ligaments with the astragalus, cuboid, navicular and to the second, third and fourth metatarsal bones. A number of the intrinsic muscles of the foot, as well as one of the secondary insertions of the tibialis posticus, are attached to the calcaneum but the muscles of surgical importance finding attachment on this bone are the gastrocnemius and soleus. These muscles are inserted through their common tendon, the tendo Achillis, into the lower part of the posterior surface of the bone. The fact that this tendon is inserted into the lower and not the upper part of the posterior surface accounts for the peculiar displacement of the fragment when fracture results from muscular action.

A small anomalous bone (the trigonum) is sometimes present just behind the posterior subastragalar joint, and if one is not familiar with its appearance it may be mistaken for a fracture, in interpreting an X-ray plate (see Fig. 776). The os calcis is ossified by two centers: one for the main portion of the bone, and the other for the epiphysis. That for the body makes its appearance during the sixth fœtal month. The center for the epiphysis is first seen during the tenth year and joins the body of the bone soon after puberty. It should not be mistaken, during this period, for a fracture of the posterior portion of the bone.

Fracture of the calcaneum may result from falls on the foot, from muscular contraction and from forcible twisting of the foot. The fracture may be transverse, or longitudinal, and not infrequently extensive comminution of the bone exists. Any portion of the bone may be broken and the posterior part is often displaced outward as well as upward. The usual break is produced by a fall from a height in which the patient lands on the foot. There is usually more or less comminution and crushing of the bone below and behind the astragalus, and not infrequently the line of fracture enters the posterior subastragalar articulation. This com-

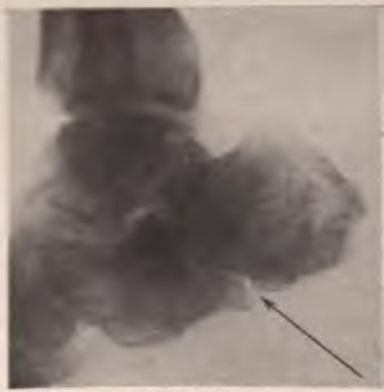


Fig. 775.

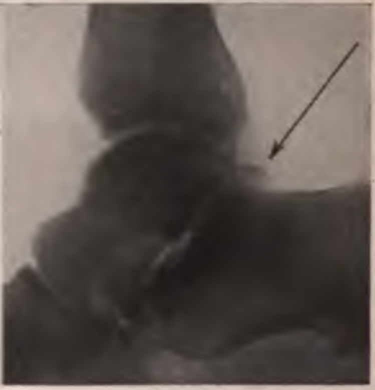


Fig. 776.

Fig. 775.—Fracture of calcaneum.

Fig. 776.—Anomalous bone present (the trigonum) which might readily be mistaken for a fracture.

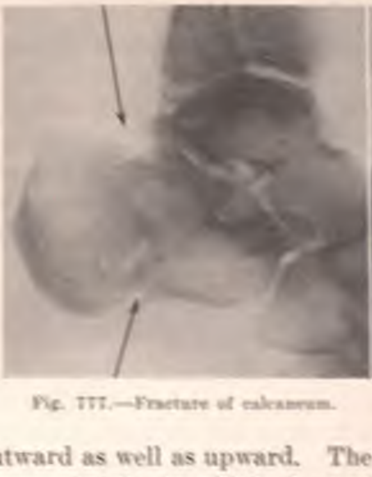


Fig. 777.—Fracture of calcaneum.

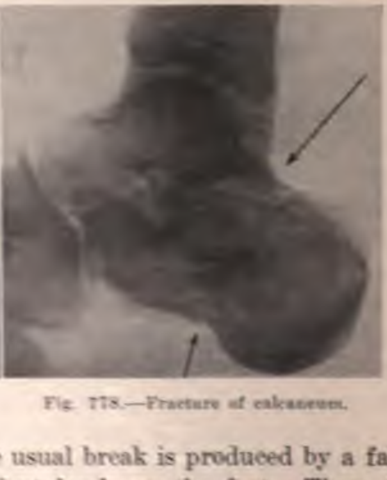


Fig. 778.—Fracture of calcaneum.

minution results in an increase in the width of the bone. Twisting of the foot and falls on the foot while inverted are said to be productive of fractures of the sustentaculum tali.

When fracture results from a twist of the foot the line of the break is more clean cut and the deformity is, as a rule, slight.

When fracture occurs as the result of overaction of the calf muscles the line of the break and the deformity are usually characteristic. A small fragment is detached from the posterior portion of the bone and displaced upward by the pull of the tendo Achillis. The upper end of the fragment commonly remains in contact with the body of the calcaneum while the lower end describes an arc upward and backward.

Isolated dislocation of the calcaneum is an extremely rare condition and is essentially the same as an incomplete subastragalar luxation. The bone is torn away from its attachments to the astragalus and cuboid and is most often displaced outward. The symptoms and treatment are practically the same as that given under the heading of "Subastragalar Luxations," page 700.

Symptoms.—The patient complains of pain in the region of the injury particularly when an attempt is made to stand on the foot. If weight is placed on the heel the direct pressure produces suffering. If the weight is placed on the ball of the foot the action of the calf muscles will pull upward on the calcaneum and the attempt will be equally painful. Swelling usually develops promptly following the accident and is noted on either side of the foot below the ankle, especially to the inner side. The foot often gives the appearance of flat-foot. The heel is broadened, elevated and often displaced outward. If there has been much comminution of the calcaneum its width will be increased and the outward displacement of the external wall may be recognized by palpation below the external malleolus. Flexion and extension of the ankle will be free but lateral motions of the foot involving the tarsal joints will be restricted, especially if the fracture has entered the posterior subastragalar articulation as it so frequently does. Crepitus can usually be elicited by manipulating the heel but it is never sharp and pronounced. This is explained by the small amount of compact tissue in the calcaneum.

In luxations of the calcaneum the heel is displaced as a whole, either inward or outward. There is abnormal mobility, no crepitus and no upward displacement as in fracture.

Diagnosis.—The diagnosis is based on the preceding symptoms but should be confirmed by the X-ray. This renders the diagnosis certain, informs the surgeon of the exact nature of the fracture and discloses complicating injuries of adjoining bones when they occur. Notwithstanding the great differences in the symptoms of the two conditions, fracture of the os calcis has been mistaken for Pott's fracture, in a number of instances of which the author knows. The normal positions and relations of the malleoli and the position of the astragalus in the tibio-fibular mortise should serve to differentiate this condition from lesions higher up. Impacted fracture of the os calcis may be quite difficult to recognize without the aid of the X-ray. If a stereoscopic Röntgenogram is made it will aid the surgeon materially in appreciating the deformity. There is considerable variation in the normal contours of different calcanea and it is therefore advisable to have a plate made of the opposite foot for the sake of comparison.

Treatment.—The treatment of fracture of the os calcis is to immobilize the foot in a position which will correct the deformity. Complete plantar flexion of the foot relieves, to a large extent, the displacing pull of the calf muscles inserted through the tendo Achillis. Fixation is usually best accomplished by means of a short, well padded, plaster stirrup. While the plaster is setting the surgeon should hold the bone in reduction: this can be done by grasping the heel and pulling it downward and slightly inward. The stirrup is moulded tightly about the tendo Achillis at the back of the ankle and when the plaster is firmly set prevents upward displacement of the posterior end of the calcaneum. The portion of the stirrup passing under the foot should be so moulded that it supports the arch of the foot. Reduction and fixation can, as a rule, be satisfactorily accomplished in this way. If, however, the pull of the calf muscles proves greater than can be overcome by this dressing a tenotomy of the tendo Achillis may be required to prevent recurrence of deformity. When considerable broadening of the calcaneum exists as a result of crushing of the bone it may be necessary to force the sides of the bone toward each other by lateral pressure beneath the malleoli. If the surgeon has a powerful grip this may be accomplished manually. An anesthetic should be employed to correct the deformity and apply the plaster stirrup.

Operative Treatment.—Aside from tenotomy (which is rarely needed) operation is called for in compound cases, and in instances in which the fragment has been detached and displaced upward by the pull of the calf muscles. Compound fracture of the calcaneum is to be treated according to the principles laid down on page 789. In severe crushing injuries, with destruction of the soft tissues covering the calcaneum, plastic operations and skin grafting may be called for to cover the bone. Necrosis may require sequestrotomy.

If a fragment, displaced by the tendo Achillis, is not readily held in position by pads (and it seldom is), operation with direct fixation of the fragment is indicated. Nailing of the fragment is not advisable because of the soft cancellous tissue in which the nail must be placed. A small mattress suture, preferably of silver wire, is probably the best method of securing the fragment in position.

Outward displacement of the external surface of the bone may give rise to an extremely tender point below the outer malleolus, when the patient resumes the use of the foot. This may call for removal, by chiseling, of the portion of bone impinging against the inner side of the malleolus. The formation of excessive callus in this region may produce the same symptoms and calls for similar treatment. A fragment or spicule of bone projecting into the sole may render walking excessively painful and calls for removal of the offending portion of bone after the diagnosis has been confirmed by the X-ray. Union with extreme deformity may be followed by such pronounced disturbances in function that operation is demanded for the relief of the condition. A transverse osteotomy of the calcaneum just behind its articulation with the astragalus, with correction of the deformity, should be done.

Operative treatment is not indicated in uncomplicated luxations of the calcaneum.

After-Treatment.—Union takes place rapidly in the calcaneum but it should be remembered that the strain imposed on the bone in walking is great, and unless the callus is solidly ossified secondary deformity may develop.

By means of a properly applied plaster stirrup the foot is immobilized for a period of from four to six weeks. Passive motion and gentle massage should be instituted at the end of two weeks. No weight should be borne on the injured foot within two or two and a half months and the resumption of function should be gradual. If the fracture has been a severe one this time may be [illegible] displacement of the heel and the [illegible] flat-foot are the results of too early use of [illegible] in walking. [illegible] and passive motion are of advantage [illegible] case many weeks before it is safe to [illegible] on the injured member. In cases in [illegible] has united in deformity a pad may be worn [illegible] heel and will often afford great comfort. [illegible] traumatic flat-foot occurs arches may be worn [illegible] support the inner side of the foot. These [illegible] are poor substitutes for union with the fragments [illegible] and will seldom be needed if the deformity [illegible] corrected and held in reduction following [illegible].

Prognosis. [illegible] treatment uncomplicated fracture of [illegible] followed by fair restoration of function. [illegible] flat-foot, restriction of motion in [illegible] metatarsalgia, pain beneath the [illegible] heel caused by a projecting fragment. [illegible] deformity is corrected following the accident [illegible] of these annoying and disabling [illegible] however, a case is seen in which the most [illegible] painstaking after-treatment have been carried [illegible] considerable disturbance in function as a [illegible] conditions. Flat-foot may be treated [illegible] shoe or if severe an osteotomy of the [illegible] and is usually followed by pro[illegible] motion in the subastragalar articulation [illegible] passive motion under anesthesia, [illegible] times if necessary. Metatarsalgia is [illegible] pass off with removal of the cause. [illegible] is relieved by removing the portion [illegible] pressure. Removal of spurs on the under [illegible] followed by prompt and complete [illegible] of disturbed function and the pos[illegible] is not so bad provided the patient [illegible] necessary corrective measures.

CHAPTER LII.

MEDIO-TARSAL LUXATIONS.

Surgical Anatomy.—Luxations sometimes, though rarely, occur at the medio-tarsal joint, the anterior portion of the foot being more or less completely displaced from the posterior. The bones entering into the articulation are proximally the astragalus and calcaneum, and distally the navicular and cuboid. The ligaments connecting these bones are very powerful and the articulation is seldom broken up except in crushes of the foot. The inner portion of this joint is a part of the anterior subastragalar articulation. The outer part of the joint (the calcaneo-cuboid) has a separate synovial cavity. The pliability of the foot depends mainly on the subastragalar and medio-tarsal articulations. Luxations of the medio-tarsal articulation have been so confounded with subastragalar luxations that only a few of the reported cases can be considered sufficiently dependable to deserve consideration. Dislocation, uncomplicated by fracture, rarely if ever occurs. The displacement may be inward, downward or outward. Upward luxation of the bones probably occurs only as a secondary element in outward luxations. In most of the cases the deformity has resembled that of an inward subastragalar luxation. The anterior portion of the foot is shortened, the inner border raised and more concave than normal. The calcaneum is not deviated as in subastragalar luxations. Crepitus is usually present as a result of complicating fracture. The anterior portion of the foot is abnormally mobile. The anterior ends of the calcaneum and astragalus produce a distinct ridge on the dorsum of the foot.

In outward luxations the foot is pronated and the scaphoid and cuboid slightly raised.

Treatment.—The treatment consists in reducing the luxation and immobilizing the parts sufficiently long to allow healing of the ligaments. Reduction should be accomplished by open incision if non-operative measures fail. The treatment, operative treatment, after-treatment and prognosis are similar to those given under "Subastragalar Luxations," page 699.

CHAPTER LIII.

FRACTURES AND LUXATIONS OF THE CUBOID, SCAPHOID AND CUNEIFORMS.

Surgical Anatomy.—The cuboid articulates with the calcaneum posteriorly and to the inner side with the external cuneiform. It supports the outer two metatarsals and is securely held in position by heavy ligaments connecting it with the adjoining bones. Fracture of the cuboid is not an uncommon lesion, especially in crushing injuries of the foot, but isolated luxation of this bone is hardly more than a surgical anomaly. Fracture usually results from direct violence to the dorsum of the foot and since the bone is practically subcutaneous the condition is often compound. The three cuneiforms are firmly bound together and to the surrounding bones by heavy ligaments and like the cuboid are rarely luxated. Fracture of these bones is usually the result of direct violence. Cases of partial displacements of the navicular and cuneiforms have been reported but the mechanism is not clear. It should be remembered that the tibialis anticus and tibialis posticus, two powerful muscles, find their main insertions on the cuneiforms and navicular.

The cuboid, navicular and cuneiforms are all composed of cancellous tissue internally, while the surface is made up of a thin layer of compact bone. They are firmly bound together by heavy ligaments and are usually fractured by direct violence to the dorsum of the foot. The soft tissues covering the dorsum of the foot are scant and the lesion is often compound. When the fracture is not compound from the first, it often becomes so later, as a result of sloughing of the integument on the dorsum of the foot.

A crushing of the tarsal or metatarsal bones is an accident not uncommonly seen among railroad employees. The foot is caught beneath the wheels of a car and more or less severely crushed. If the train is moving with much speed the foot is crushed and amputated. If the rate at which the train is moving is slow the foot may be pushed aside and only partially crushed.

Treatment.—In fractures of the anterior bones of the tarsus, whatever deformity is present should be corrected and the foot immobilized on a plaster sole as shown in Fig. 787. This splint should extend from the middle of the leg to a point beyond the toes. A plaster cast should not be used since secondary sloughing is not uncommon and the skin on the dorsum of the foot should be open to inspection during the after-treatment. The damage to the soft tissues is often more important than the fracture. If sloughing occurs the parts should be frequently dressed and the sloughing area kept as aseptic as possible. Granulations should be cultivated and stimulated by balsam of Peru and in removing the dressings the surgeon should avoid injury to these delicate granulations.

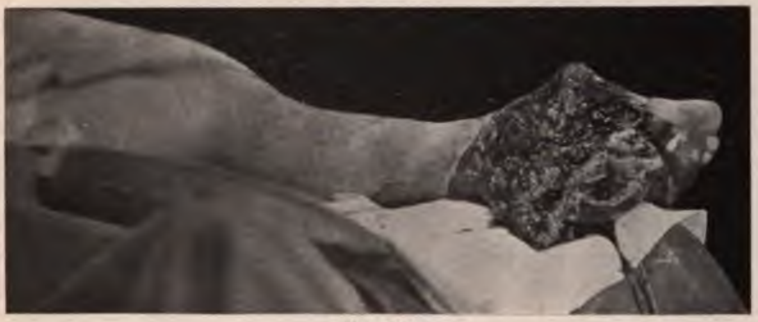


Fig. 779.

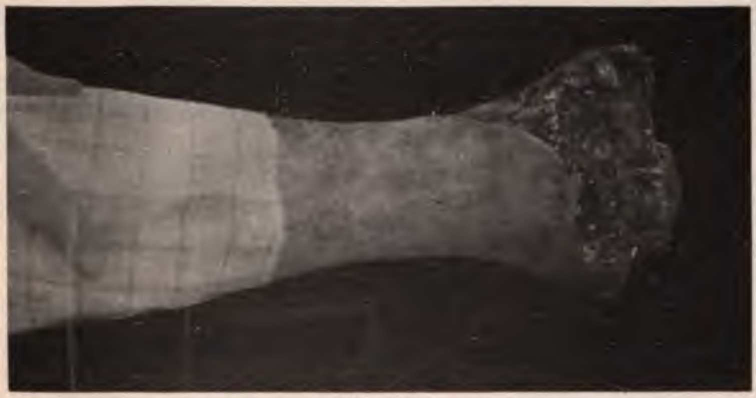


Fig. 780.

Figs. 779 and 780.—Crushing injuries of feet sustained beneath car-wheels. Crushing disarticulation through tarso-metatarsal joint. In the upper plate (Fig. 779) the lower portion of the foot is not completely severed though the tissues are so thoroughly mangled that the circulation is destroyed and amputation is necessary. In the lower plate (Fig. 780) the lower portion of the foot was completely severed at the time of the accident.

The use of antiseptics such as bichlorid of mercury will do more harm than good. While healing and union are taking place the surgeon should see to it that the plaster sole properly maintains the arch of the foot.

Operative Treatment.—Operation is frequently indicated because the fracture is compound but rarely to accomplish reduction. The treatment of compound cases is the same in fractures of these bones as has already been indicated under the heading of "The Treatment of Compound Fractures" on page 789. In severe crushes of the foot immediate amputation is not infrequently demanded.

After-Treatment.—The length of the period of immobilization varies greatly with the severity of the fracture and whether or not it is compound. If the arch of the foot has been involved, by the fracture or luxation, weight should not be borne on the injured member inside of six weeks. In instances in which this has not occurred the patient may begin the gradual resumption of function at the end of three or four weeks. If sloughing of the tissues on the dorsum of the foot takes place union is usually delayed and the period of fixation should be prolonged accordingly.

Prognosis.—In severe crushes of the foot amputation may be necessary. In instances in which the trauma has not been severe, with little displacement, and no sloughing of the soft tissues, complete restoration of function is the rule. Surprisingly good function not infrequently follows even in compound cases and in instances in which the soft tissues have sloughed.

CHAPTER LIV.

TARSO-METATARSAL LUXATIONS.

Surgical Anatomy.—The articulation between the distal tarsals (three cuneiforms and cuboid) and the bases of the five metatarsals is firmly supported by heavy ligaments, and luxations are rare. Displacements of the bases of the metatarsals may occur, but the causative trauma is more likely to produce fracture in this region. The anterior end of the long plantar ligament is attached to the bases of the second, third and fourth metatarsals. All five metatarsals may be luxated as a row, or the base of any one may be dislocated alone. The displacement is almost invariably dorsal, so that the base of the metatarsal may be palpated on the dorsum of the foot. Luxation of the first metatarsal alone is the most common single luxation. The dorsum of the foot is slightly shortened. Divergent luxations have been noted in which the bases of the outer metatarsals are displaced outward, while the inner bones of this row are displaced inward.

Symptoms.—The dorsum of the foot is slightly shortened, and a little more prominent than normal. Pain is experienced in walking and when pressure is made on the ball of the foot by the surgeon. Crepitus is absent unless the luxation is accompanied by fracture, which is not uncommon. If the foot is carefully compared with the opposite foot the deformity will be noted at the level of the tarso-metatarsal articulation. Pressure on the ball of the foot may increase the deformity on the dorsum, as the corresponding metatarsal is displaced upward and backward.

Diagnosis.—If swelling is pronounced it may be difficult to differentiate between luxations of this joint and fractures of the adjoining bones, without the aid of the X-ray. When the traumatic reaction is not great the landmarks on the foot will serve to disclose the nature and position of the lesion.

Treatment.—Traction on the foot will accomplish reduction. The foot should be fixed for a period sufficiently long to allow healing of the ligaments. The treatment of luxations at this joint is similar to other dislocations in the tarsus.

Fracture of the calcaneum may result from falls on the foot, from muscular contraction and from forcible twisting of the foot. The fracture may be transverse, or longitudinal, and not infrequently extensive comminution of the bone exists. Any portion of the bone may be broken and the posterior part is often displaced outward as well as upward. The usual break is produced by a fall from a height in which the patient lands on the foot. There is usually more or less comminution and crushing of the bone below and behind the astragalus, and not infrequently the line of fracture enters the posterior subastragalar articulation. This com-

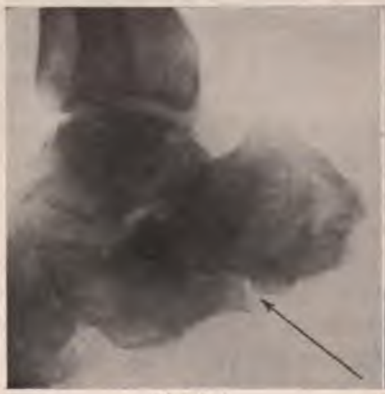


Fig. 775.

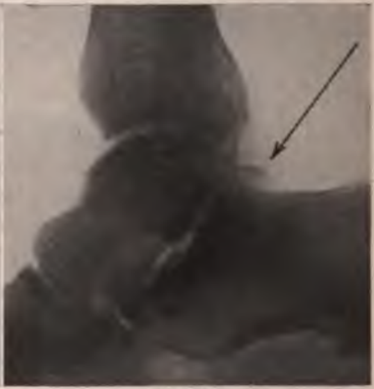


Fig. 776.

Fig. 775.—Fracture of calcaneum.

Fig. 776.—Anomalous bone present (the trigonum) which might readily be mistaken for a fracture.

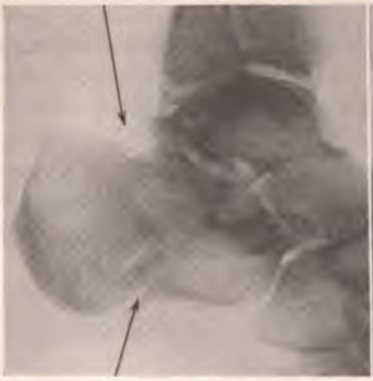


Fig. 777.—Fracture of calcaneum.

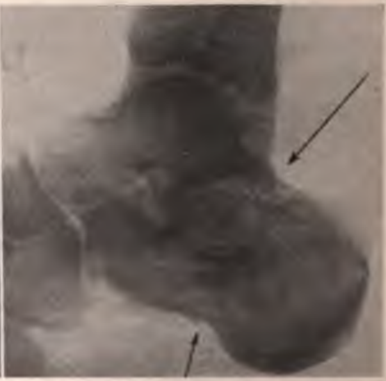


Fig. 778.—Fracture of calcaneum.

minution results in an increase in the width of the bone. Twisting of the foot and falls on the foot while inverted are said to be productive of fractures of the sustentaculum tali.

When fracture results from a twist of the foot the line of the break is more clean cut and the deformity is, as a rule, slight.

When fracture occurs as the result of overaction of the calf muscles the line of the break and the deformity are usually characteristic. A small fragment is detached from the posterior portion of the bone and displaced upward by the pull of the tendo Achillis. The upper end of the fragment commonly remains in contact with the body of the calcaneum while the lower end describes an arc upward and backward.

Isolated dislocation of the calcaneum is an extremely rare condition and is essentially the same as an incomplete subastragalar luxation. The bone is torn away from its attachments to the astragalus and cuboid and is most often displaced outward. The symptoms and treatment are practically the same as that given under the heading of "Subastragalar Luxations," page 700.

Symptoms.—The patient complains of pain in the region of the injury particularly when an attempt is made to stand on the foot. If weight is placed on the heel the direct pressure produces suffering. If the weight is placed on the ball of the foot the action of the calf muscles will pull upward on the calcaneum and the attempt will be equally painful. Swelling usually develops promptly following the accident and is noted on either side of the foot below the ankle, especially to the inner side. The foot often gives the appearance of flat-foot. The heel is broadened, elevated and often displaced outward. If there has been much comminution of the calcaneum its width will be increased and the outward displacement of the external wall may be recognized by palpation below the external malleolus. Flexion and extension of the ankle will be free but lateral motions of the foot involving the tarsal joints will be restricted, especially if the fracture has entered the posterior subastragalar articulation as it so frequently does. Crepitus can usually be elicited by manipulating the heel but it is never sharp and pronounced. This is explained by the small amount of compact tissue in the calcaneum.

In luxations of the calcaneum the heel is displaced as a whole, either inward or outward. There is abnormal mobility, no crepitus and no upward displacement as in fracture.

proximal portion of this bone. Fracture of the metatarsals is not, as a rule, accompanied by impaction and displacement, as is the case when the metacarpals are broken.

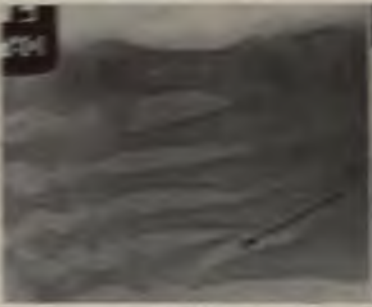


Fig. 783.

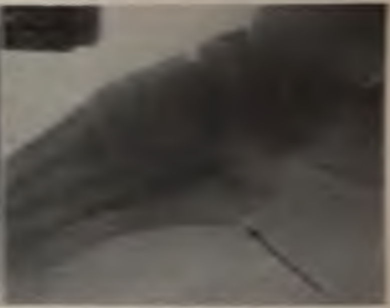


Fig. 784.

Fig. 783.—Oblique fracture of the shaft of the fifth metatarsal.
Fig. 784.—Fracture of the base of the fifth metatarsal.

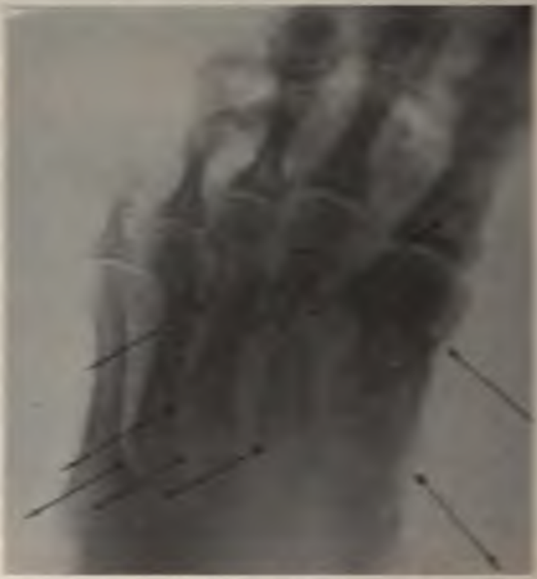


Fig. 785.—Compound crushing injury of metatarsus in which eight distinct fractures may be seen. Result of eight-ton girder falling on foot. Same case as shown in Fig. 786.

Symptoms.—The symptoms vary greatly with the severity of the injury. In cases produced by comparatively slight trauma, and in those due to muscular action the symptoms will be moderate in which the fragment has been detached and displaced upward by the pull of the calf muscles. Compound fracture of the calcaneum is to be treated according to the principles laid down on page 789. In severe crushing injuries, with destruction of the soft tissues covering the calcaneum, plastic operations and skin grafting may be called for to cover the bone. Necrosis may require sequestrotomy.

If a fragment, displaced by the tendo Achillis, is not readily held in position by pads (and it seldom is), operation with direct fixation of the fragment is indicated. Nailing of the fragment is not advisable because of the soft cancellous tissue in which the nail must be placed. A small mattress suture, preferably of silver wire, is probably the best method of securing the fragment in position.

Outward displacement of the external surface of the bone may give rise to an extremely tender point below the outer malleolus, when the patient resumes the use of the foot. This may call for removal, by chiseling, of the portion of bone impinging against the inner side of the malleolus. The formation of excessive callus in this region may produce the same symptoms and calls for similar treatment. A fragment or spicule of bone projecting into the sole may render walking excessively painful and calls for removal of the offending portion of bone after the diagnosis has been confirmed by the X-ray. Union with extreme deformity may be followed by such pronounced disturbances in function that operation is demanded for the relief of the condition. A transverse osteotomy of the calcaneum just behind its articulation with the astragalus, with correction of the deformity, should be done.

Operative treatment is not indicated in uncomplicated luxations of the calcaneum.

After-Treatment.—Union takes place rapidly in the calcaneum but it should be remembered that the strain imposed on the bone in walking is great, and unless the callus is solidly ossified secondary deformity may develop.

By means of a properly applied plaster stirrup the foot is immobilized for a period of from four to six weeks. Passive motion and gentle massage should be instituted at the end of two weeks. No weight should be borne on the injured foot within two or two and a half months and the resumption of function should be gradual. If the fracture has been a severe one this time may be increased. Secondary upward displacement of the heel and the development of static flat-foot are the results of too early use of the foot in walking. Free active and passive motion are of advantage in the treatment of the case many weeks before it is safe to allow the full weight to be borne on the injured member. In cases in which the calcaneum has united in deformity a pad may be worn in the shoe beneath the heel and will often afford great comfort. In instances in which traumatic flat-foot occurs arches may be worn within the shoe to support the inner side of the foot. These measures, however, are poor substitutes for union with the fragments in proper position, and will seldom be needed if the deformity has been properly corrected and held in reduction following the injury.

Prognosis.—With proper treatment uncomplicated fracture of the os calcis should be followed by fair restoration of function. The most important sequelæ are: flat-foot, restriction of motion in the subastragalar articulation, metatarsalgia, pain beneath the outer malleolus, and painful heel caused by a projecting fragment. The more perfectly the deformity is corrected following the accident the less the probability of these annoying and disabling sequelæ. Occasionally, however, a case is seen in which the most perfect reduction and painstaking after-treatment have been carried out and yet there is considerable disturbance in function as a result of one or more of these conditions. Flat-foot may be treated by means of arches within the shoe or if severe an osteotomy of the calcaneum may be performed and is usually followed by pronounced improvement. The motion in the subastragalar articulation may be increased by forcible passive motion under anesthesia, which may be repeated many times if necessary. Metatarsalgia is a result of flat-foot and will pass off with removal of the cause. Pain beneath the outer malleolus is relieved by removing the portion of bone causing the pressure. Removal of spurs on the under surface of the calcaneum will be followed by prompt and complete relief. Considering the causes of disturbed function and the possibility of relief the prognosis is not so bad provided the patient is willing to submit to the necessary corrective measures.

CHAPTER LII.

MEDIO-TARSAL LUXATIONS.

Surgical Anatomy.—Luxations sometimes, though rarely, occur at the medio-tarsal joint, the anterior portion of the foot being more or less completely displaced from the posterior. The bones entering into the articulation are proximally the astragalus and calcaneum, and distally the navicular and cuboid. The ligaments connecting these bones are very powerful and the articulation is seldom broken up except in crushes of the foot. The inner portion of this joint is a part of the anterior subastragalar articulation. The outer part of the joint (the calcaneo-cuboid) has a separate synovial cavity. The pliability of the foot depends mainly on the subastragalar and medio-tarsal articulations. Luxations of the medio-tarsal articulation have been so confounded with subastragalar luxations that only a few of the reported cases can be considered sufficiently dependable to deserve consideration. Dislocation, uncomplicated by fracture, rarely if ever occurs. The displacement may be inward, downward or outward. Upward luxation of the bones probably occurs only as a secondary element in outward luxations. In most of the cases the deformity has resembled that of an inward subastragalar luxation. The anterior portion of the foot is shortened, the inner border raised and more concave than normal. The calcaneum is not deviated as in subastragalar luxations. Crepitus is usually present as a result of complicating fracture. The anterior portion of the foot is abnormally mobile. The anterior ends of the calcaneum and astragalus produce a distinct ridge on the dorsum of the foot.

In outward luxations the foot is pronated and the scaphoid and cuboid slightly raised.

Treatment.—The treatment consists in reducing the luxation and immobilizing the parts sufficiently long to allow healing of the ligaments. Reduction should be accomplished by open incision if non-operative measures fail. The treatment, operative treatment, after-treatment and prognosis are similar to those given under "Subastragalar Luxations," page 699.

CHAPTER LIII.

FRACTURES AND LUXATIONS OF THE CUBOID, SCAPHOID AND CUNEIFORMS.

Surgical Anatomy.—The cuboid articulates with the calcaneum posteriorly and to the inner side with the external cuneiform. It supports the outer two metatarsals and is securely held in position by heavy ligaments connecting it with the adjoining bones. Fracture of the cuboid is not an uncommon lesion, especially in crushing injuries of the foot, but isolated luxation of this bone is hardly more than a surgical anomaly. Fracture usually results from direct violence to the dorsum of the foot and since the bone is practically subcutaneous the condition is often compound. The three cuneiforms are firmly bound together and to the surrounding bones by heavy ligaments and like the cuboid are rarely luxated. Fracture of these bones is usually the result of direct violence. Cases of partial displacements of the navicular and cuneiforms have been reported but the mechanism is not clear. It should be remembered that the tibialis anticus and tibialis posticus, two powerful muscles, find their main insertions on the cuneiforms and navicular.

The cuboid, navicular and cuneiforms are all composed of cancellous tissue internally, while the surface is made up of a thin layer of compact bone. They are firmly bound together by heavy ligaments and are usually fractured by direct violence to the dorsum of the foot. The soft tissues covering the dorsum of the foot are scant and the lesion is often compound. When the fracture is not compound from the first, it often becomes so later, as a result of sloughing of the integument on the dorsum of the foot.

A crushing of the tarsal or metatarsal bones is an accident not uncommonly seen among railroad employees. The foot is caught beneath the wheels of a car and more or less severely crushed. If the train is moving with much speed the foot is crushed and amputated. If the rate at which the train is moving is slow the foot may be pushed aside and only partially crushed.

Treatment.—In fractures of the anterior bones of the tarsus, whatever deformity is present should be corrected and the foot immobilized on a plaster sole as shown in Fig. 787. This splint should extend from the middle of the leg to a point beyond the toes. A plaster cast should not be used since secondary sloughing is not uncommon and the skin on the dorsum of the foot should be open to inspection during the after-treatment. The damage to the soft tissues is often more important than the fracture. If sloughing occurs the parts should be frequently dressed and the sloughing area kept as aseptic as possible. Granulations should be cultivated and stimulated by balsam of Peru and in removing the dressings the surgeon should avoid injury to these delicate granulations.

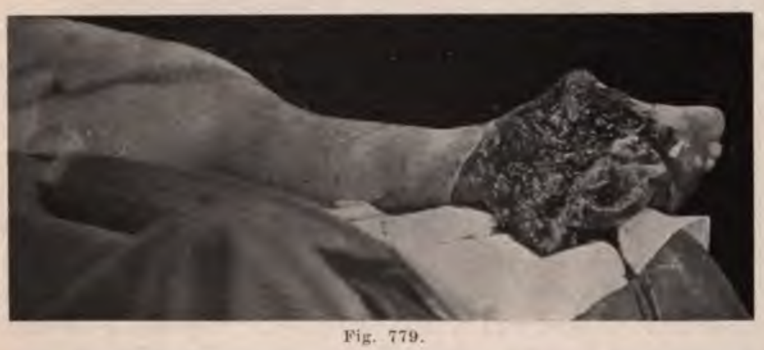


Fig. 779.

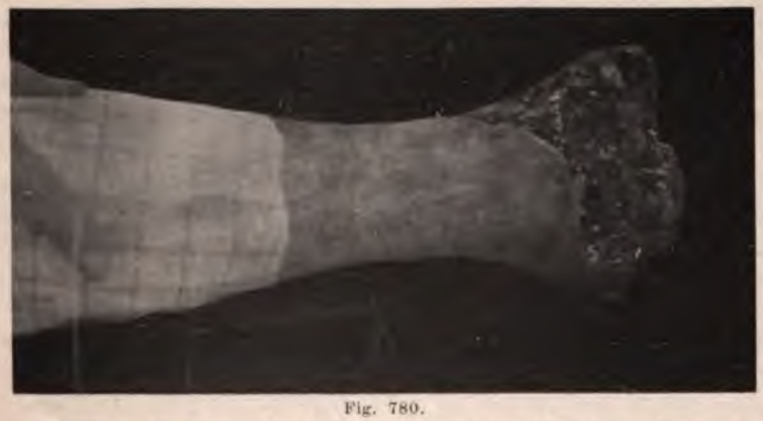


Fig. 780.

Figs. 779 and 780.—Crushing injuries of feet sustained beneath car-wheels. Crushing disarticulation through tarso-metatarsal joint. In the upper plate (Fig. 779) the lower portion of the foot is not completely severed though the tissues are so thoroughly mangled that the circulation is destroyed and amputation is necessary. In the lower plate (Fig. 780) the lower portion of the foot was completely severed at the time of the accident.

CHAPTER LIV.

TARSO-METATARSAL LUXATIONS.

Surgical Anatomy.—The articulation between the distal tarsals (three cuneiforms and cuboid) and the bases of the five metatarsals is firmly supported by heavy ligaments, and luxations are rare. Displacements of the bases of the metatarsals may occur, but the causative trauma is more likely to produce fracture in this region. The anterior end of the long plantar ligament is attached to the bases of the second, third and fourth metatarsals. All five metatarsals may be luxated as a row, or the base of any one may be dislocated alone. The displacement is almost invariably dorsal, so that the base of the metatarsal may be palpated on the dorsum of the foot. Luxation of the first metatarsal alone is the most common single luxation. The dorsum of the foot is slightly shortened. Divergent luxations have been noted in which the bases of the outer metatarsals are displaced outward, while the inner bones of this row are displaced inward.

Symptoms.—The dorsum of the foot is slightly shortened, and a little more prominent than normal. Pain is experienced in walking and when pressure is made on the ball of the foot by the surgeon. Crepitus is absent unless the luxation is accompanied by fracture, which is not uncommon. If the foot is carefully compared with the opposite foot the deformity will be noted at the level of the tarso-metatarsal articulation. Pressure on the ball of the foot may increase the deformity on the dorsum, as the corresponding metatarsal is displaced upward and backward.

Diagnosis.—If swelling is pronounced it may be difficult to differentiate between luxations of this joint and fractures of the adjoining bones, without the aid of the X-ray. When the traumatic reaction is not great the landmarks on the foot will serve to disclose the nature and position of the lesion.

Treatment.—Traction on the foot will accomplish reduction. The foot should be fixed for a period sufficiently long to allow healing of the ligaments. The treatment of luxations at this joint is similar to other dislocations in the tarsus.

Fractures of the metatarsals are almost invariably the result of direct blows and are frequently seen in crushes of the foot. Fracture from indirect violence does, however, occasionally occur, especially of the first and fifth. A misstep or twist of the foot may produce fracture of one of the metatarsals. The injury has been noted in soldiers at the end of long, forced marches. The base of the fifth metatarsal is prominent, and falls on the foot, with the member inverted, not uncommonly result in fracture of the

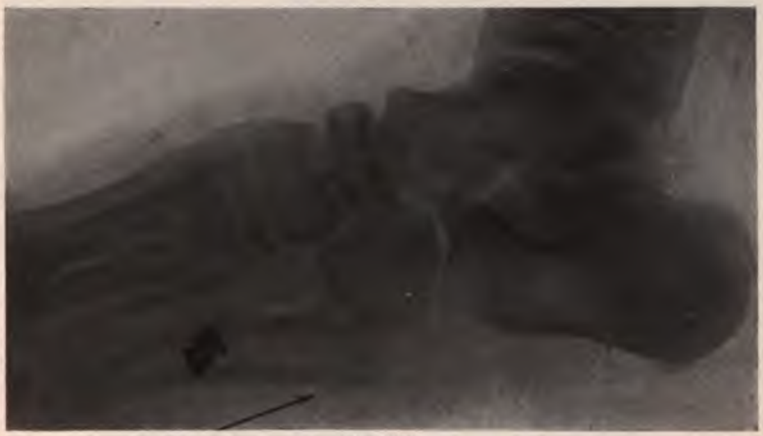


Fig. 781.

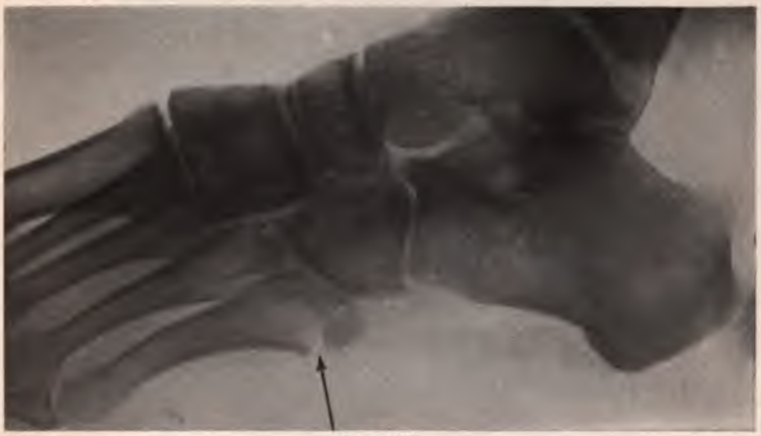


Fig. 782.

Figs. 781 and 782.—Show fractures of the bases of the fifth metatarsals.

proximal portion of this bone. Fracture of the metatarsals is not, as a rule, accompanied by impaction and displacement, as is the case when the metacarpals are broken.

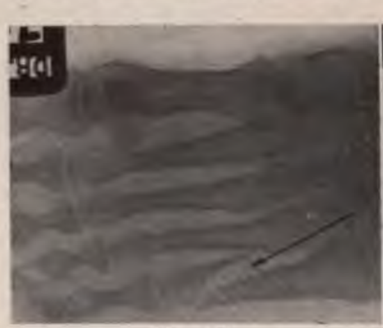


Fig. 783.

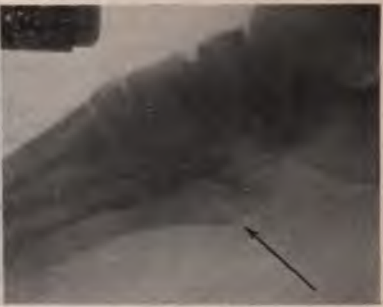


Fig. 784.

Fig. 783.—Oblique fracture of the shaft of the fifth metatarsal.
Fig. 784.—Fracture of the base of the fifth metatarsal.

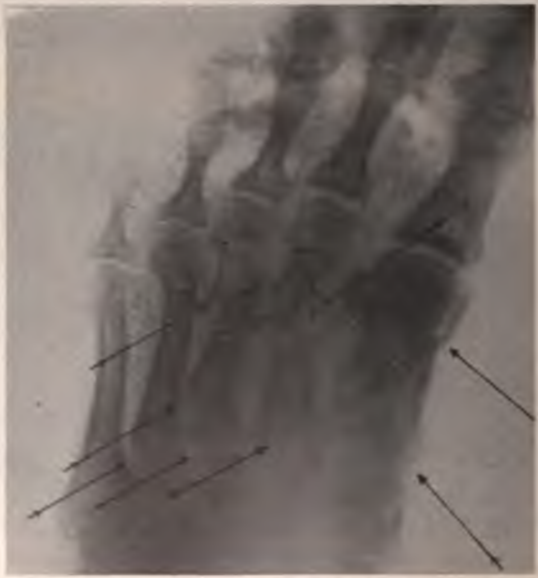


Fig. 785.—Compound crushing injury of metacarpus in which eight distinct fractures may be seen. Result of eight-ton girder falling on foot. Same case as shown in Fig. 787.

Symptoms.—The symptoms vary greatly with the severity of the injury. In cases produced by comparatively slight trauma, and in those due to muscular action the symptoms will be moderate and more or less typical. In severe crushes of the foot it is not uncommon to be able to see the fractured bones in among the lacerated and mangled tissues of the foot. In such instances the fractures present are only of secondary importance as compared with the damage done to the soft parts. Sloughing of the tissues on the dorsum of the foot is not an uncommon sequel when the causative trauma has been severe and direct. In crushes of the

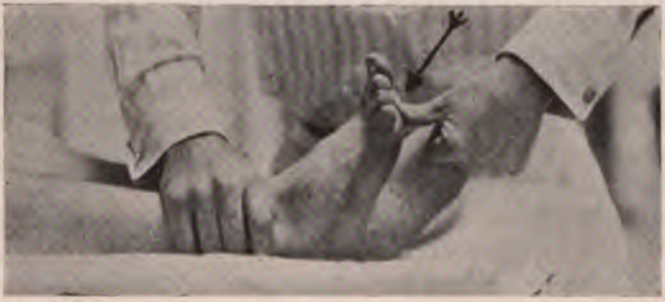


Fig. 786.—Method of detecting fractures in the metacarpals. Pressure on the metacarpal head in the line of the long axis of the bone will elicit pain in the presence of fracture.

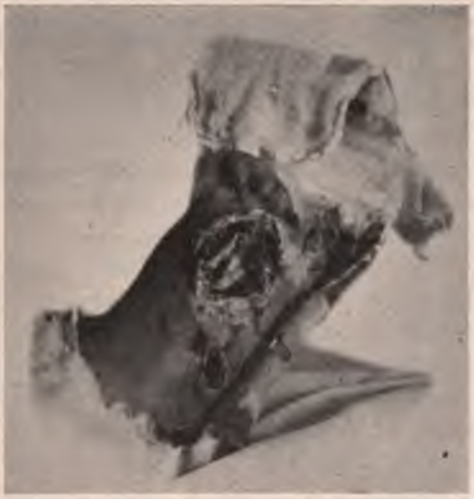


Fig. 787.—Crushing injury of the foot. An eight-ton girder fell on the foot as it was resting on the edge of a curb, producing eight fractures in the metacarpal bones. (See X-ray, Fig. 785.) The wound seen in the plate resulted from subsequent sloughing and it was possible at one time to see four of the fractures of the metatarsals. Wound healed by cultivation of granulation tissue rather than attention to antisepsis. Result: union in all the fractures with closure of the wound and perfect recovery of function. Patient walks without limp.

foot there will, of course, be complete loss of function. In simple cases pain, tenderness, swelling, crepitus and abnormal mobility will be present. The suffering is increased if the patient attempts to stand on the foot, and in some instances the fragments may be heard grating against one another as the attempt is made. Deformity is rarely pronounced. In one exceptional compound case seen by the author there was a fracture of the shaft of the first metatarsal, a little below the middle, and the distal fragment was turned completely around on a transverse axis, so that the articular end rested against the distal end of the proximal fragment.

Diagnosis.—There is usually little difficulty in recognizing a fracture of one or more of these bones. Their dorsal surfaces are practically subcutaneous, and if the case is seen early much can be learned by direct palpation. If the swelling and traumatic reaction are well advanced before the surgeon is called, the parts may be exquisitely tender, and under such circumstances it is preferable to determine the presence of fracture by the use of the X-ray, rather than to administer an anesthetic and establish the diagnosis by palpation and manipulation.

If pressure is made on the ball of the foot (between the toes and the ball) and toward the base of the bone (that is, in the direction of the axis of the metatarsal) pain may be produced at the seat of fracture in the corresponding bone. Pressure should be made in this way over the head of each metatarsal.

Treatment.—The foot should be placed on a plaster sole which is moulded so that it properly supports the arch of the foot. This splint should extend from the middle of the leg to a point beyond the toes. Traumatic reaction should be controlled by the intermittent application of the ice cap, and by keeping the foot in the elevated position. If deformity exists it should be corrected before the plaster sole is applied.

Operative Treatment.—Compound cases are common and the operative treatment in these cases is practically the same as that given on page 712 under "Fractures and Dislocations of the Cuboid, Scaphoid and Cuneiforms." Open treatment to correct deformity in simple cases is practically never indicated.

After-Treatment.—Union takes place in simple cases in three to four weeks. Weight bearing should be only gradually resumed, since ventral bowing may occur if the first metatarsal alone or more than one of the other metatarsals has been broken, and the patient walks too soon. Hot applications, passive motion and massage will hasten the time when the patient will be able to enjoy free use of the foot.

Prognosis.—The severity of these lesions varies greatly, and accordingly the outlook will depend on the amount of damage done. Simple, uncomplicated injuries should be followed by complete restoration of function. Severe crushing injuries may require immediate amputation.

CHAPTER LVI.

FRACTURES AND LUXATIONS OF THE PHALANGES.

Surgical Anatomy.—The structure of the bones of the toes is similar to that found in the fingers. The toes may be broken in crushes of the foot, and resemble the condition as occurring in the metatarsals. The toes are practically always broken by direct violence. The accident is common among laborers and results from heavy objects being dropped on the foot. A not uncommon form of injury is one in which the toes are caught in a moving elevator. The great toe usually suffers most and the crushing of the parts is severe when produced in this way. Stubbing of the toes against some projecting object, while the patient is barefooted, is frequently responsible for fracture of one or more of the phalanges, especially that of the little toe. Luxations of the toes are rare and resemble those seen in the fingers.

Symptoms.—The amount of disability is almost entirely dependent on the severity of the causative trauma. In simple fracture of the little toe the patient is usually able to get about with little difficulty although pain may be severe immediately following the accident. On the other hand severe crushing injuries, such as sustained in the usual elevator accident, completely disable the patient. Crepitus, pain and swelling are present. Crepitus may be difficult to elicit if the fracture is in the distal phalanx, because of the splinting effect of the nail.

Treatment. The parts should be immobilized on a plantar splint. The displacement is usually moderate and can be corrected without difficulty. In fractures of the great toe the patient should be prevented from bearing weight on the foot until union is solid. In fracture of the smaller toes the patient may be allowed about as soon as the traumatic reaction has subsided. The great toe is an important factor in walking but the lesser toes have little to do with the usefulness of the foot. If fibrous union takes place in one of the smaller toes there will be no subsequent disturbance in function. When the little toe alone is fractured it will usually not be necessary to employ a splint in the treatment of the condition. If cotton is placed between the little toe and the adjoining digit, and the injured toe strapped in position with adhesive, the necessary immobilization will have been accomplished. In compound, crushing injuries the important element is the damage done to the soft tissues, and the case must be treated accordingly. Gangrene may develop in one or more of the toes if the crushing has been severe, and amputation may be necessary.

Prognosis.—In simple uncomplicated cases the prognosis is good. If the accident results in the loss of the great toe there may be a limp, more or less noticeable in the patient's gait.

PART IV.

SPECIAL SUBJECTS.

CHAPTER LVII.

TERMS AND DEFINITIONS.

Fracture.—No better definition can be given than the meaning of the Latin word (*frangere*, to break) from which the term is derived. A breaking of bone or cartilage.

Dislocation or *Luxation.*—Is a condition in which the articular surfaces are completely displaced from each other. These terms are often loosely used, and in many instances an incomplete displacement of the articular surfaces is spoken of as a dislocation when it should be designated as a subluxation.

Subluxations are dislocations in which the articular surfaces remain partly in contact with each other.

Complete and incomplete are terms used to indicate the degree of fracture or luxation. In incomplete fractures the line of fracture only partially separates the fragments.

Congenital fractures and luxations are conditions which exist at birth. In many instances it is difficult to state whether or not the lesion was intra-uterine. Congenital fractures and luxations may be the result of prenatal disease, defective development or of trauma at birth, or of a combination of these causes.

Spontaneous fractures and dislocations occur as a result of disease or paralysis. In some instances, notably fracture of the hip, the bone may break under normal strain as a result of the absorption and rarefication of bone which takes place in the aged.

Pathologic fractures are caused by diseases of the bone such as osteo-sarcoma, carcinoma, osteo-myelitis, etc.

Pathologic luxations result from diseases which cause degeneration of the ligaments or alterations of the articular surfaces.

Recurrent or habitual luxations are conditions in which the same dislocation takes place repeatedly, following incomplete healing of the ligaments after the initial lesion. Recurrent luxations are common in the shoulder joint following improper treatment of the first displacement.

Diastasis and distraction are terms used to indicate a condition in which the joint surfaces are forcibly torn from each other and remain separated without resulting deformity. A good example of diastasis is sometimes seen in the lower tibio-fibular articulation

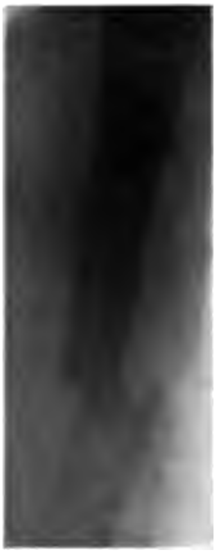


Fig. 738.

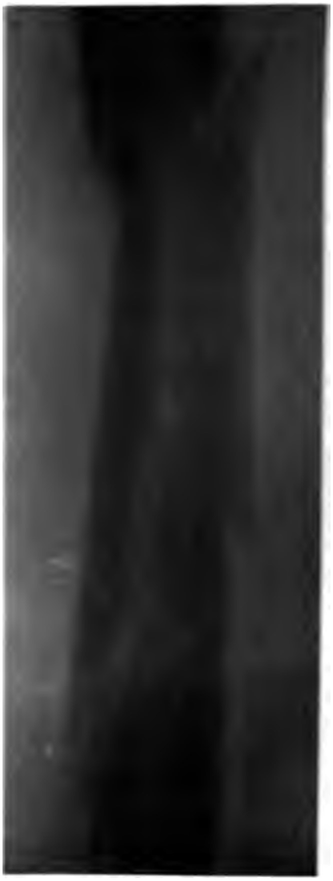


Fig. 739.

Fig. 738. Example of a simple transverse fracture.
Fig. 739. Example of multiple fracture of the shaft.

when the ligaments are torn and the lower ends of the tibia and fibula separated.

The term *compound* or *open* is used when the fracture or luxation is connected with the outside air by means of a wound. The wound may be made by the vulnerant body penetrating to the bone, or the end of the fragment or articular surface of the bone may penetrate the skin from within.

The term *closed* is used in contradistinction to open or compound.

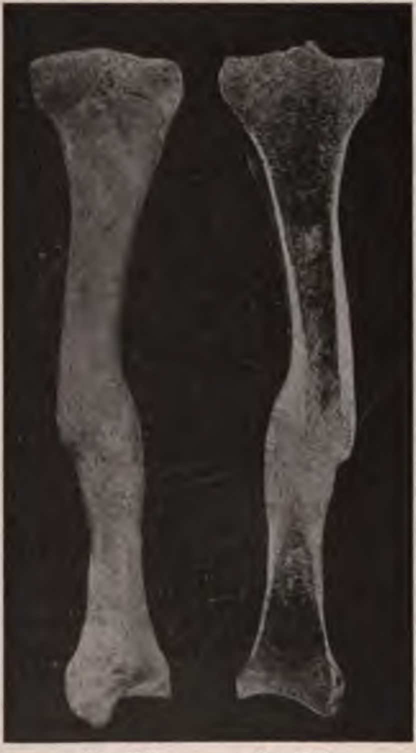


Fig. 790. Fig. 791.

Figs. 790 and 791.—Surface form and section of fracture united in deformity. Old fractured tibia sawed in the coronal plane. Note how the rough fractured surfaces not originally in apposition have been absorbed, filled in and rounded off, as the middle of the callus became more dense. When union takes place with deformity, as in this case, the callus is of necessity heavier and more dense than when good reduction has been accomplished. This specimen was obtained from the dissecting room and is probably many years old yet the medullary canal has not reopened. In fractures of the shafts of long bones the medullary canal reopens some years following the injury provided the reduction is good. In this case the deformity is pronounced and the medullary canal remains occluded by the internal callus. A good example of the reopening of the canal is seen in the X-ray plates (Figs. 636 to 639).

The term *simple* is used in contradistinction to both compound and complicated.

The term *complicated* is rather indefinite in its meaning. It is used when the fracture is compound or open and is also employed to indicate associated injury to arteries, veins, nerves or muscles. It is also used when the fracture is infected.

A *green-stick* fracture is one in which the line of fracture resembles that seen when a green-stick is broken. The bone is bent and the fracture involves only the convex side of the shaft. Many fractures are called green-stick which are in reality of the subperiosteal type.

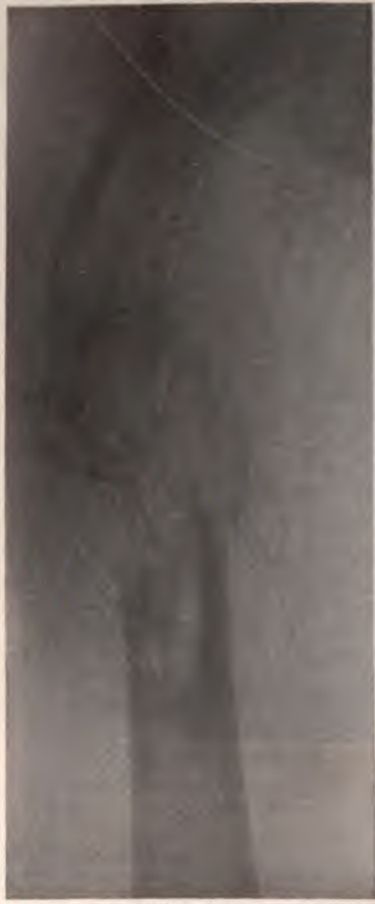


Fig. 792.

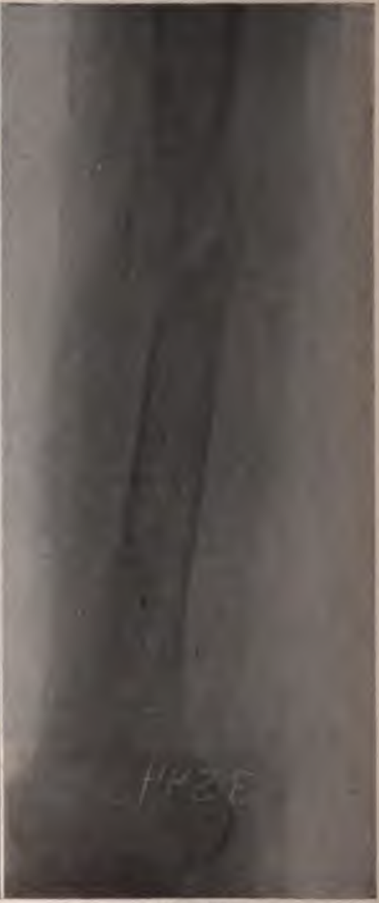


Fig. 793.

Fig. 792.—Carcinoma of the humerus with spontaneous fracture.
Fig. 793.—Carcinoma of the humerus with spontaneous fracture.

Subperiosteal fracture.—This term is used when the fracture is

Fig. 794.—Carcinoma of the lower end of the femur with extensive destruction of bone.

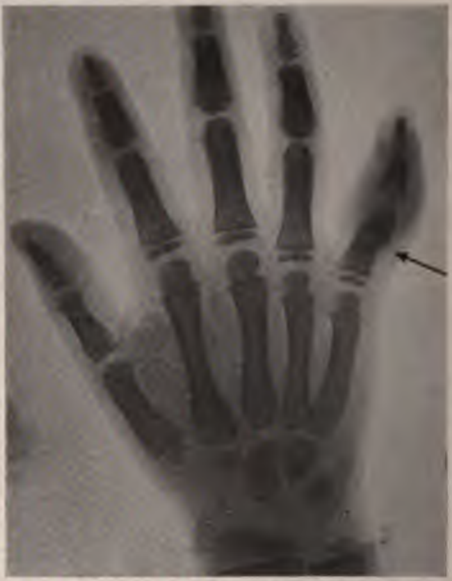


Fig. 795.—Syphilitic dactylitis with spontaneous fracture.

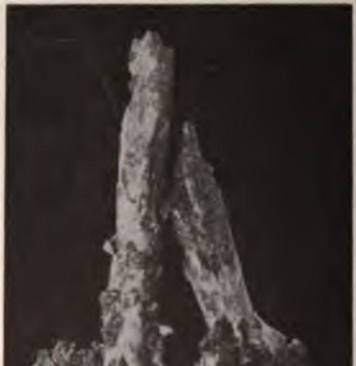


Fig. 796.—Spontaneous fracture following osteosarcoma.

not accompanied by appreciable tearing of the periosteum or displacement of the fragments. It occurs in children and is the result of bending force applied to the bone. When this type of violence is applied to a young bone (young bones are tough rather than brittle) the convex side of the shaft is under tension strain while the concave side is under compression strain. Fracture may

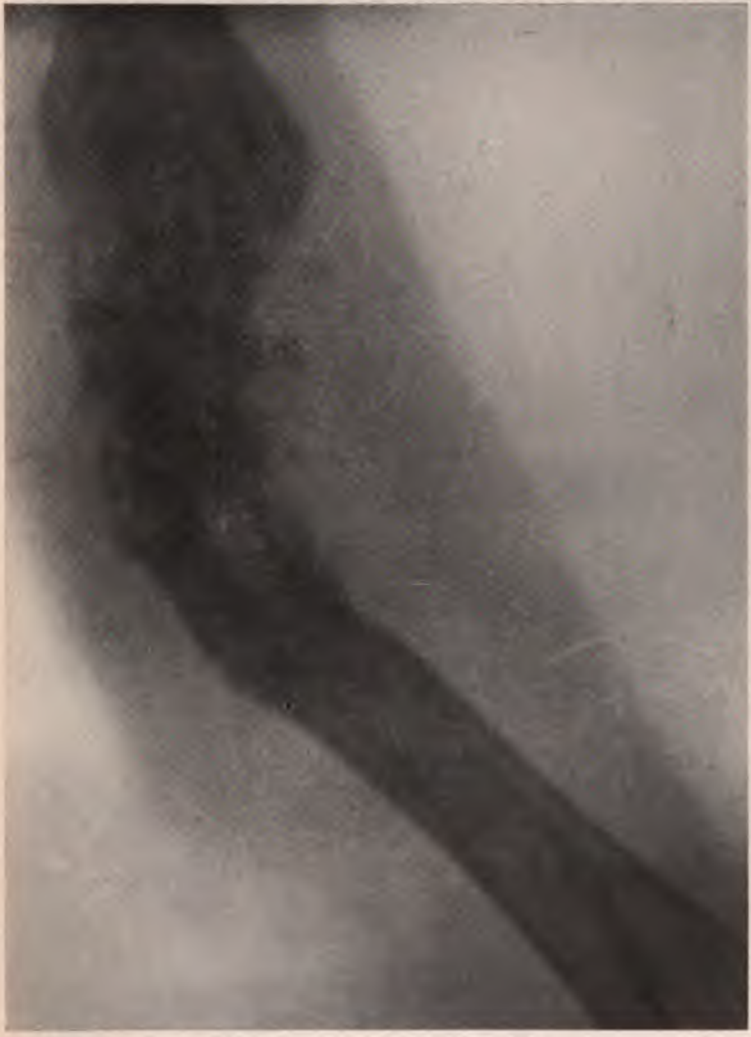


Fig. 797.—Osteocarcinoma with spontaneous fracture. Much destruction of bone.

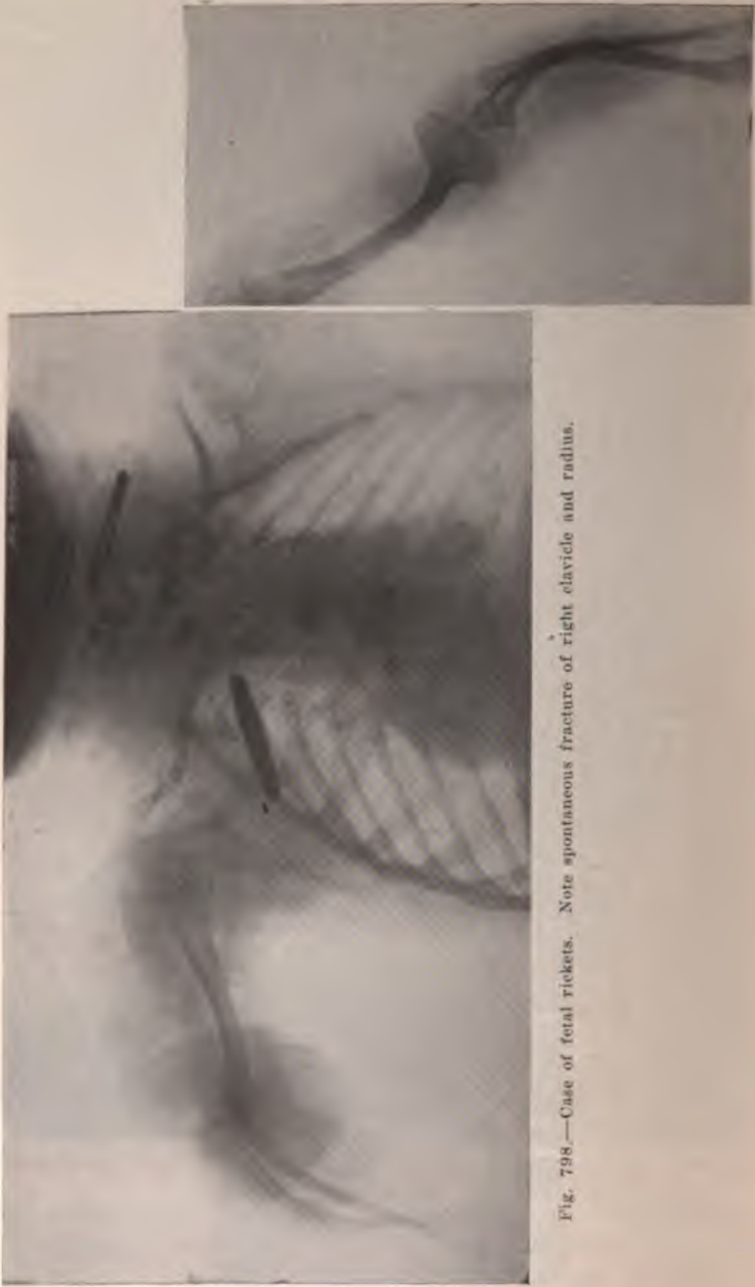


Fig. 798.—Case of fetal rickets. Note spontaneous fracture of right clavicle and radius.

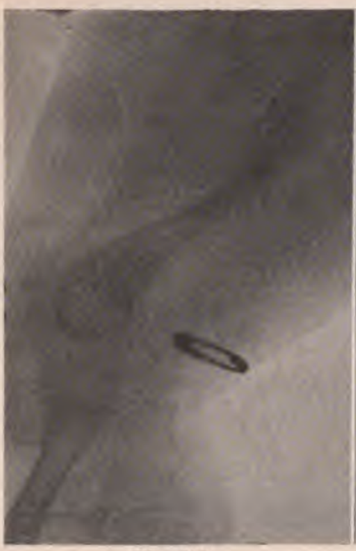


Fig. 799.

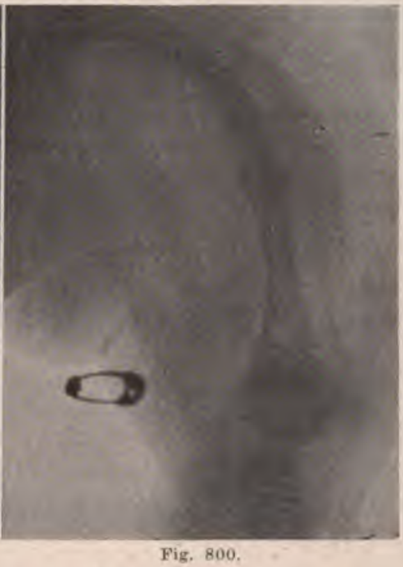


Fig. 800.

Fig. 799.—Same case as shown in Fig. 798. Note fracture of femur.
Fig. 800.—Same case. Note fracture of femur.

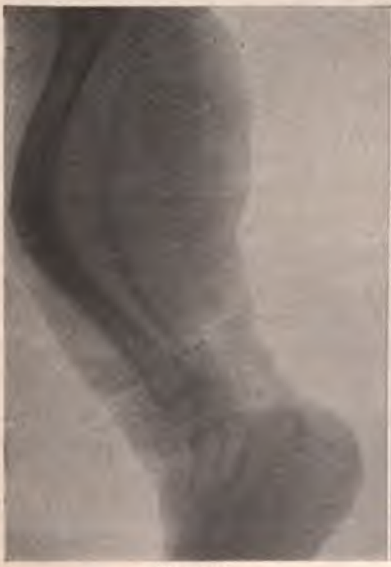


Fig. 801.

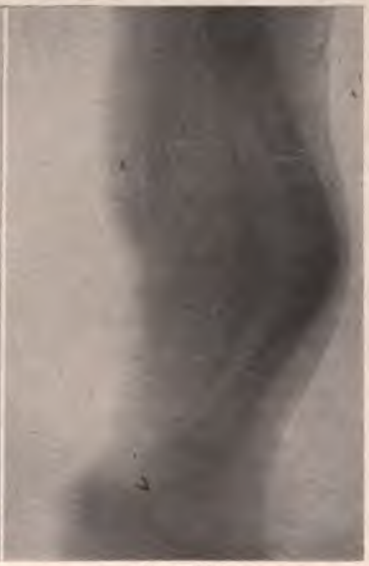


Fig. 802.

Fig. 801.—Same case. Note bowing of tibia and point in shaft which is ready to break with the slightest strain.

Fig. 802.—Same case. Same condition as seen in tibia of opposite leg in Fig. 801.

occur on the convex side from tension or on the concave side from compression. When the former type of fracture occurs and is incomplete we have the typical green-stick fracture. When the latter type occurs we have the subperiosteal form of fracture. The difference is well illustrated by the manner in which different forms of iron break. Wrought iron girders break on the concave side from "buckling," while steel girders break on the convex side with clean fracture. The more brittle the material the more likely the fracture is to begin on the convex side of the column and to be complete. The more rapid the bending the greater the probability of a complete fracture and of the break beginning on the convex side.

Various terms are used to indicate the nature of the fracture, the character of the deformity and the line of the break. Such commonly used terms as: comminuted, multiple, transverse, oblique, spiral, overriding, angular, depressed, etc., are self-explanatory.

CHAPTER LVIII.

THE USE OF THE X-RAY.

BY H. G. STOVER, M.D.

After the lapse of some eighteen years since Röntgen's discovery, it ought not to be required, in a work upon fractures and dislocations, to insist upon the absolute necessity for the routine use of this indispensable diagnostic means in every instance of possible bone or joint injury.

Yet even in this day, when the benefits of Röntgenology are available in so many localities, the use of this agent is far from as general as it should be.

In the early days of the Röntgen ray there was some excuse for the surgeon who did not rely upon it: the users of the ray were not in possession of efficient apparatus; exposures were long, and often resulted in harm; and, owing to imperfect technique and small experience, the information afforded by a Röntgenologic examination was in many instances incomplete, and at times misleading.

These excuses do not hold now; in every center of population there are installations capable of giving useful Röntgenograms, and men who are competent to make the examinations skillfully and without danger to the patients.

The advantages of the Röntgenologic examination are many and vital.

The Röntgen examination does away with the need for manipulation of injured parts in the attempt to elicit pain, crepitus and preternatural mobility; it not only affords all the information of value to be gained from the ordinary methods of examination, but it brings forth facts impossible to be elicited in any other way: certain fractures without displacement; certain impacted fractures; certain incomplete fractures; certain fractures, which, by their very nature cannot give the usual clinical signs; it reveals the interposition of small fragments between the ends of fractured bones; and avoids the bruising and laceration of tissues which must occur in some instances if there be a prolonged manipulative examination.

It has been argued by some that a surgeon ought not allow his manual dexterity to suffer the atrophy of disuse, by relying upon the Röntgen ray; one might as well say that an internist ought not use the microscope to look for plasmodia in the blood, but ought rather nurse his skill in eliciting subjective and objective clinical symptoms upon which to formulate his diagnosis. At the same time, it must be insisted that the Röntgen examination is not to supplant the clinical methods: rather must it supplement them. The skilled hand of the surgeon has done its wonders through the ages; it cannot be neglected now; the practised eye discovers external signs of internal conditions in a marvelous way as evidenced by the photographs in this book.

The time is coming when failure to make appropriate use of Röntgenology, when accessible, will be counted as negligence, and this not only in surgery, but in many departments of internal medicine. Even the laity are coming now to criticise their attendants for delay or neglect in this matter.

After attempted reposition of fracture or dislocation, the Röntgen examination affords a means of ascertaining if position is correct without disturbing retentive dressings or apparatus, enables one to watch the course of healing, and to know the final anatomical result.

In many of the fractures met with, a clinical diagnosis sufficiently accurate for preliminary treatment can be made; in these cases the Röntgen examination should be made after reposition in order to check up the clinical diagnosis and to make certain that satisfactory reposition has been accomplished. But there are not a few instances in which the Röntgen examination should be made before anything else is done; in this class are many of the injuries about the elbow, hip, and pelvis, and those severe traumata in which there is suspicion of grave damage to vital soft tissues, and further injury through manipulation might result in gangrene, or other detrimental sequelæ.

As the Röntgen ray produces no sensory impression upon the retina, it is necessary to use intermediate means to transform the results of its energy into visible records.

There are three physical factors which render this possible:

First: all substances absorb the Röntgen ray practically in relative amounts corresponding directly to the ratio existing between their atomic weights.

Second: the Röntgen ray causes certain substances to fluoresce.

Third: the Röntgen ray has the power of producing a paralyzing effect, or a latent, developable image, upon the chemicals used in the sensitive emulsion of photographic plates and certain photographic papers.

If a substance is so placed that it will intercept rays directed toward a screen coated with fluorescent material, or a photographic plate, the absorption which occurs leaves areas on the screen or emulsion, which are not affected; these areas on the fluorescent screen are dark; in the emulsion of the plate no latent image is produced; if the substance under examination is made up of areas of various densities, the amount of fluorescence upon the screen or of alteration in the silver salt of the emulsion of a plate, in corresponding areas, varies in an inverse proportion to the densities of these areas, or in direct ratio to the amount of rays which these areas permit to pass.

At the present time the fluoroscope is not used in this branch of surgical Röntgenology, except for roughly and quickly estimating the approximate location of a foreign body, or obtaining some general facts regarding a bone injury; the screen image is not so rich in detail as is that upon the plate; it can be studied during only a short period of time; it is not a permanent record; its frequent use is dangerous to the operator; long or repeated exposure may lead to injury of the patient's skin, as for example, when the operator, the attending physician, perhaps a consulting surgeon, and probably from one to a dozen relatives and friends, must all "have a look." On the other hand the sensitive plate gives all the details; it can be studied as long or as often as needed and at any time; it is a permanent record of the condition; it is demonstrable evidence that such an examination has been made; in addition to this, the accumulation of a large library of plates furnishes rich material for scientific study and for the writing of papers.

The great part of Röntgen diagnosis in medicine and surgery must be done by specialists in this line, and indeed before long there will be subspecialties in Röntgenology, so great is the field and so complicated the technical details of diagnosis-making. Most physicians and surgeons will find it impracticable to make their own Röntgen examinations. A complete equipment is costly in apparatus and space and its maintenance expensive. One's own patients will not contribute as liberally to this for these examinations as they will do when referred to a specialist for the purpose, and men cannot give time from a busy practice to carry out the work. The physician who does not have reasonably ready access to a competent Röntgenologist may well, however, prepare and equip himself to examine fractures and dislocations by this method. He will not need the powerful generating machines, the complicated auxiliary apparatus or the costly tubes necessary for instantaneous Röntgenography of the lungs and stomach. Yet let not such an one imagine that he is taking up a simple problem! For this man the author would advise the Rose Portable Coil (Fig. 803). It may be used on either direct or alternating current; it is of the compact "suit-case" type and can be carried in the hand for short distances without overfatigue, so it may be used either in the office or at the beside where electric current is available. In Fig. 804 is shown a larger apparatus of the same type. It is more powerful but is

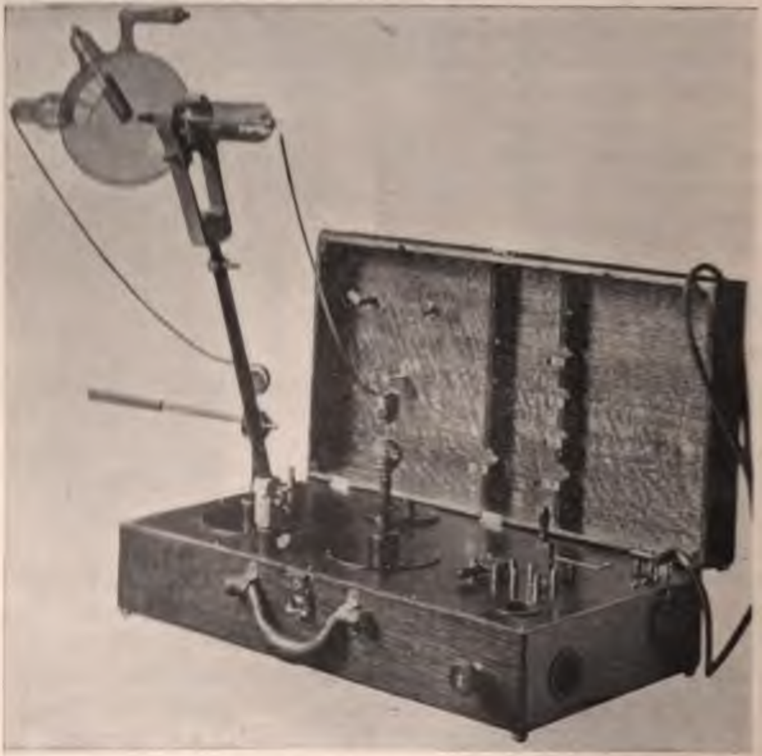


Fig. 803.—The Rose portable coil.

more weighty and heavier fuses must be placed in house circuits in which it is used. Another box for carrying the Crooke's tube and the plate-holders is a convenience. The apparatus requires a special type of Crooke's tube, calculated to suppress inverse current (Fig. 805).

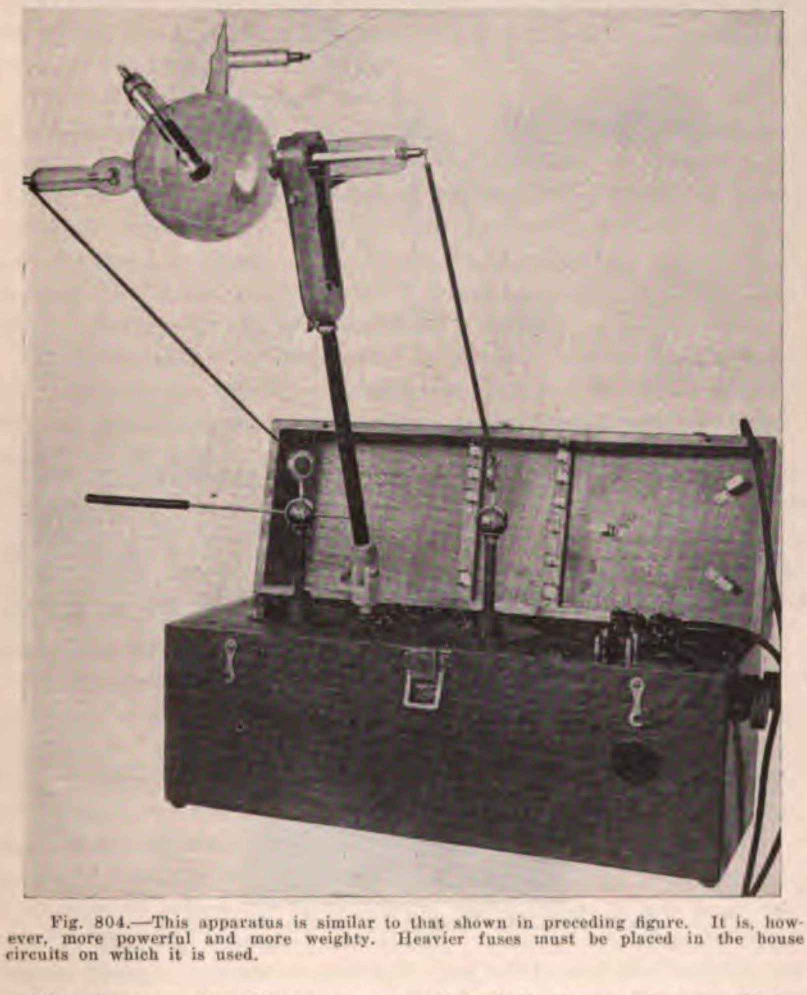


Fig. 804.—This apparatus is similar to that shown in preceding figure. It is, however, more powerful and more weighty. Heavier fuses must be placed in the house circuits on which it is used.

The Cramer, the Forbes, or the "Agfa" X-ray plates will be found quite satisfactory, permitting of some latitude in exposure time.

These plates are to be enclosed in the black and yellow envelopes, opaque to ordinary actinic light, which may be procured from the plate makers. Always put the plate in the black envelope (in the dark-room, of course) so that the film of the plate is next to the smooth side of the envelope; then put the black envelope into the yellow one so that their smooth and unprinted sides are together; this is important, as in this way one is always certain as to which side of the package carries the film side of the plate. If Röntgenograms are made with the film side of the plate down in some examinations and up in others, when using envelopes, there might be no way of knowing, in a subsequent study of the plate, whether the right or left side of the body had been examined, a point which it is quite necessary to know when making reports to insurance companies, or when the physician is called to the witness stand. It is a very good plan to mark the plates, at the time of making the exposure, by means of leaden letters "L" and "R."

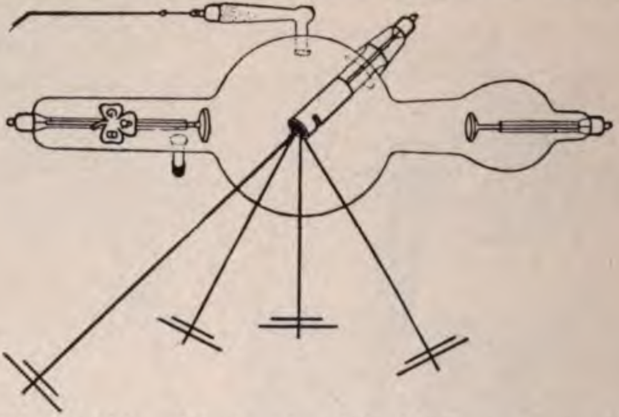


Fig. 805.—Special type of Crookes tube, calculated to suppress inverse current.

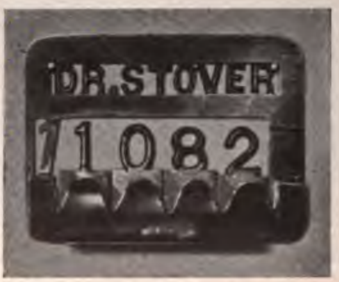


Fig. 806.—Metallic numbers for marking X-ray plates.

For several reasons it is quite important that plates be carefully so marked that their future identification is always positive. Metallic numbers (Fig. 806) may be placed on the plate at the time of the exposure, thus obtaining a Röntgenogram of the number as a part of the image produced; if this is not practicable the number of the plate or the patient's name, should be written upon the film side of the plate, in the dark-room, with a lead pencil, immediately before developing it.

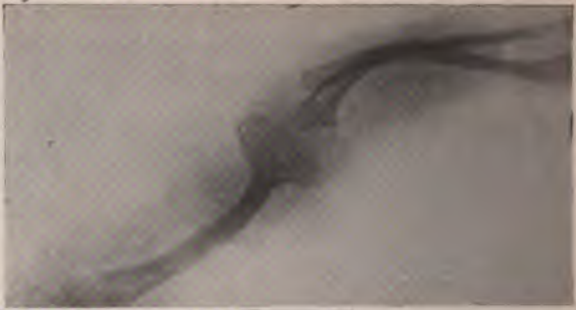
When the Röntgenogram has been made, the following points should be noted upon the envelope, for a record: name of patient; address; occupation; if a minor or a dependent, the name and address of the financially responsible party; the date; the part examined; the nature of the view—whether antero-posterior, postero-anterior, lateral, etc.; the condition suspected; the diagnosis; and other facts may be added if desired, such as, history of the injury; description of the dressings applied, etc.

The plates should be filed away in a safe place in such a way that they will be readily accessible for future reference. Filing may be done according to number, or in groups of "parts of body," or in groups of "lesions found." An index of such a nature that plates may be found easily, should also be kept.

Do not permit patients or others to carry away your plates; you may want them badly yourself some day. The plate is the most important part of your record of your work; it may be needed for study of the progress of a case; it may be needed in court; in time your plates form a valuable library as already stated.

The author does not permit his plates to be introduced in evidence as "exhibits" in medico-legal cases; when the author is on the stand and is asked to show his plates to the jury, he says to the Judge, "May it please your Honor, these plates are a part of my professional records; they are necessary to me as such, and as material for scientific study; I therefore do not desire to introduce them into evidence as exhibits, but simply to use them as diagrams, by means of which to demonstrate the opinion I am here to give." This has always been allowed without question by the Court.

Prints, if they are of such a nature that they will show the conditions according to the opinion of the expert, may be introduced as exhibits. Personally the author does not think plates or prints ought to be made exhibits in evidence. The Röntgenologist is not



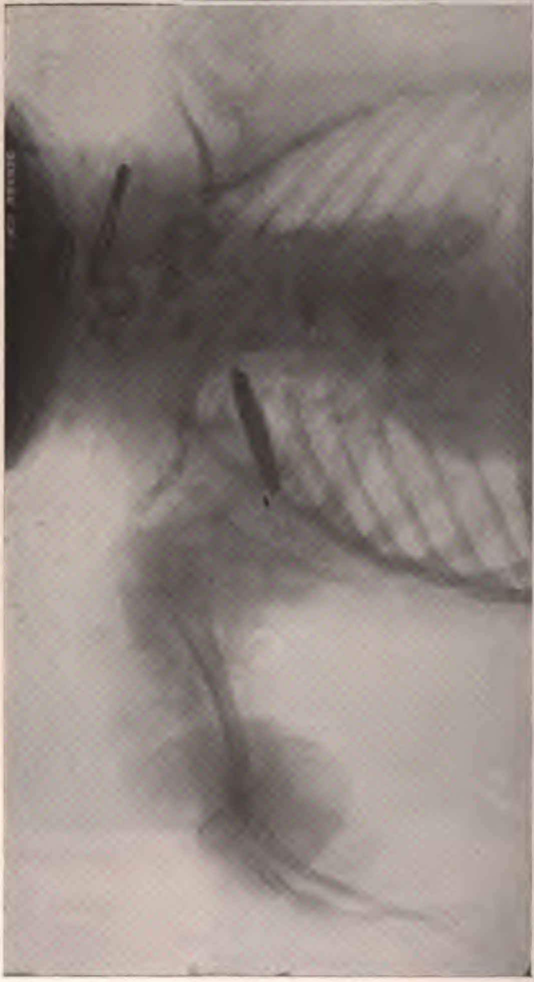


Fig. 798.—Case of fetal rickets. Note spontaneous fracture of right clavicle and radius.

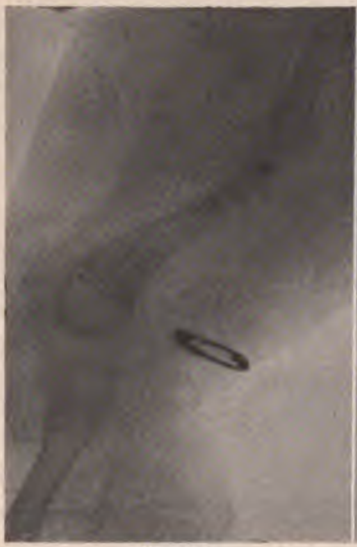


Fig. 799.

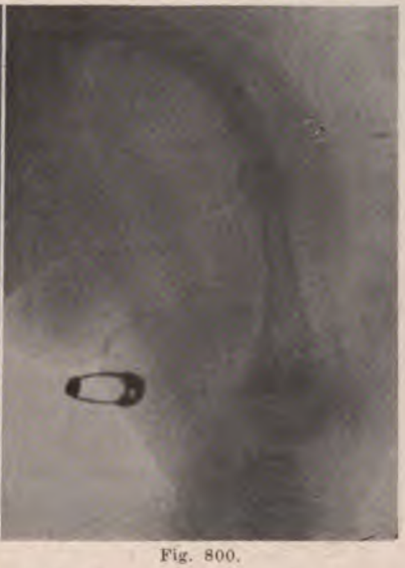


Fig. 800.

Fig. 799.—Same case as shown in Fig. 798. Note fracture of femur.
Fig. 800.—Same case. Note fracture of femur.

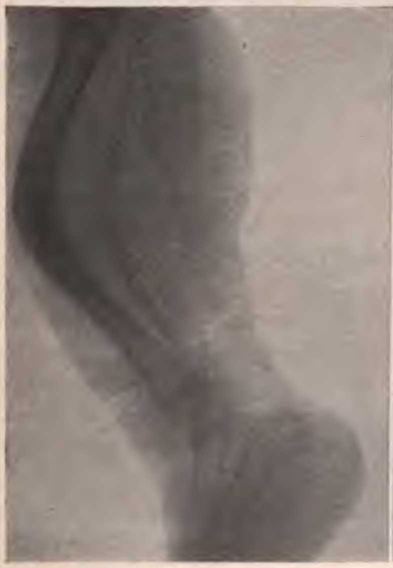


Fig. 801.

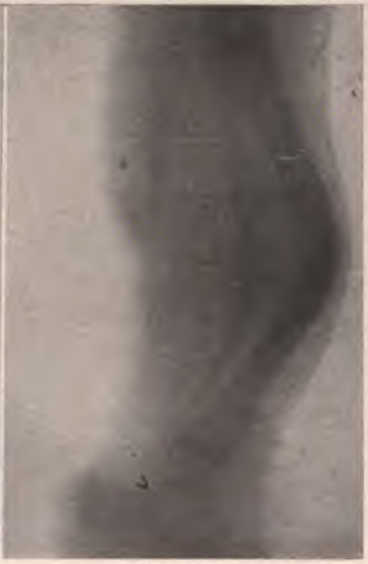


Fig. 802.

Fig. 801.—Same case. Note bowing of tibia and point in shaft which is ready to break with the slightest strain.

Fig. 802.—Same case. Same condition as seen in tibia of opposite leg in Fig. 801.

the center of the object, as in Fig. 810. The Röntgenogram resulting from this pose, shown in Fig. 811, gives a distorted image of the object. The outline of the image is far from being circular in form, and the image of the smaller sphere is not at the center of the image of the large sphere.

From these facts we may deduce a general rule for so posing as to avoid distortion:

The object and the plate should be as close together as possible; they should be as far as possible from the target (consistent with securing sufficient quantity of ray); the rays falling from the target perpendicularly upon the plate should pass through the center of the object.

A distance of from eighteen to twenty-four inches between tube and plate is usually used.

Now this cannot be an absolute rule; it must be infringed upon in respect of the relation of the principal axis of rays and the center of the object, at times. For example: a patient with a suspected fracture of the neck of the femur, exhibiting considerable eversion of the lower extremity; as the patient lies on his back, the plane of the neck of the femur is not parallel with the surface of the plate placed underneath; rays passed through the neck of the femur and falling perpendicularly upon the plate, would give a foreshortened image of the neck, largely covered by the superimposed shadow of the greater trochanter; therefore the exposure to show a fracture of the neck of the femur in such a case as this must be made with the target of the tube outside of a perpendicular from the plate passing up through the neck; this oblique direction of the rays will show the full length of the neck.

In making a Röntgenogram of the ankle-joint, antero-posterior view, with the toe pointing directly upward, perpendicularly to the plate beneath, the target should be placed a little to the outside of the perpendicular, in order not to superimpose the shadows of the lower ends of the tibia and fibula.

The rays proceeding from different Crookes tubes are not always the same in quality; the quality of ray from any given tube will vary from time to time. There is a variation in quantity depending upon the exciting current; beside this, there are all degrees of variation in penetrating power, dependent largely, apparently, upon the nature of the vacuum in the tube, other things being equal.

In general we speak of the rays as being "soft," "medium," or "hard," and we use the same terms in describing the tubes.

The soft ray comes from a "soft" tube, of low (comparative) vacuum; these rays are emitted in large quantity, have a considerable chemical action, but are of low penetrating power. These are the rays which quickly lead to dermatitis if permitted to act too long on the tissues. They produce very contrasty Röntgenograms of thin parts.

It is worse than useless to attempt the production of a Röntgenogram of a thick part with a soft tube by unduly prolonging the exposure; this simply over-doses the tissues with rays which are all absorbed, and the only result will be a "burn."

The hard rays come from a "hard" tube, one of high vacuum; they are emitted in relatively less quantity, have less chemical action, but are very penetrating.

The medium rays come in large quantity from a tube of (comparative) medium vacuum, and are best for general purposes, giving good bone-structure and contrast between bone and soft tissue. For bone work in very thick parts a harder ray is better. If too hard a tube is used, the extremely penetrating rays being so little absorbed by the bony tissue, give a flat negative without contrast between bone and soft tissue.

The user of the Röntgen ray should be very careful to protect himself from its deleterious effects. This is a matter of the utmost gravity; repeated exposures are bound to produce the specific results upon the tissues; the Röntgen ray is not a plaything. A serious dermatitis results invariably in carcinoma with a strong metastatic tendency, and the death roll of Röntgenologists, with several yet living whose names will soon be added to it, is already too large.

In addition to the fact of the danger to life from incautious exposure, is the fact that the ray affects the reproductive organs in such a way as to produce sterility (not impotentia).

Fluoroscopes are now provided with lead glass for protection, and opaque gloves, aprons, gowns, etc., may be procured. There are shields of heavy lead glass, white oxide of lead, or rubber compound which may be placed directly about the tube, and which are quite opaque to the ray.

In estimating the time of exposure for different parts, one should consider: the thickness or density of the part; the distance of the tube; the penetrating power, or hardness of the ray used; the amount of current passing through the tube; the kind of plate used (some are much more rapid than others). The use of an intensifying screen cuts down the time from one-fifth to one-tenth, but it also cuts down in the same proportion the allowance of latitude for error in calculation.

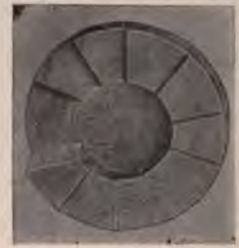


Fig. 812.—Radio-chronometer.

There are scales for measuring the penetrating power of the ray; the best of these is the Benoist radio-chronometer (Fig. 812); with this, when viewed through the fluoroscope, or its image studied upon the plate, a comparison is made of the color produced by rays

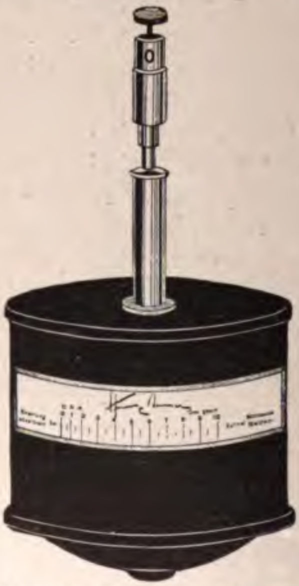


Fig. 813.—The Bauer qualimeter.

which have passed through pieces of aluminum of different thickness, with that produced by rays which have passed through a piece of silver of a standard thickness.

The hardness of the rays may be measured by means of the Bauer Qualimeter, a sort of electro-static torsion balance (Fig. 813).

A special milliamperemeter is used for measuring the quantity of high voltage current passing through the tube.

Thus quite an accurate technique may be built up. Experience soon teaches how to estimate the values of the various factors so that the calculation with these becomes automatic with the experienced operator.

With small apparatus, such as has been recommended for the amateur Röntgenologist, it is necessary to make rather long exposures in order to produce good plates of the thicker parts; thus the quiet of the part may be disturbed by respiratory movements, or muscular twitchings may occur, or nervous patients may find it impossible to remain quiet. The exposure time may be shortened by the use of intensifying screens as has already been said. Such a screen consists usually of a sheet of cardboard upon which has been laid a smooth coat of some substance which fluoresces when exposed to the Röntgen ray. This fluorescent light is much more active actinically than is the Röntgen ray itself. In use, the chemical side of the screen is placed in very perfectly intimate contact with the film of the plate (a special plate-holder is necessary); this

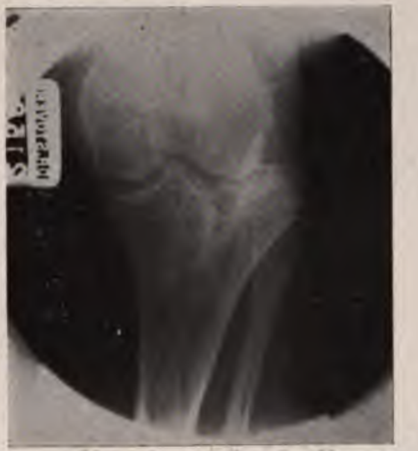


Fig. 814.—Linear fracture of upper end of tibia.

plate-holder is placed under the part to be examined, preferably with the glass side of the plate toward the patient and tube; the exposure is then made, and very much shorter than when the screen is not used; in the dark room the holder is opened, the screen quickly removed and placed in its container and the plate developed. Unless a fine screen is used and great care taken that the exposure is neither too long nor too short by a very small margin, the result will not be satisfactory; if there is even a slight overexposure the image will be "grainy" and the lines of bone-structure will not be sharp and clear. The technical difficulties are multiplied by the screen, but its use will be of value when examining thick parts with small apparatus.

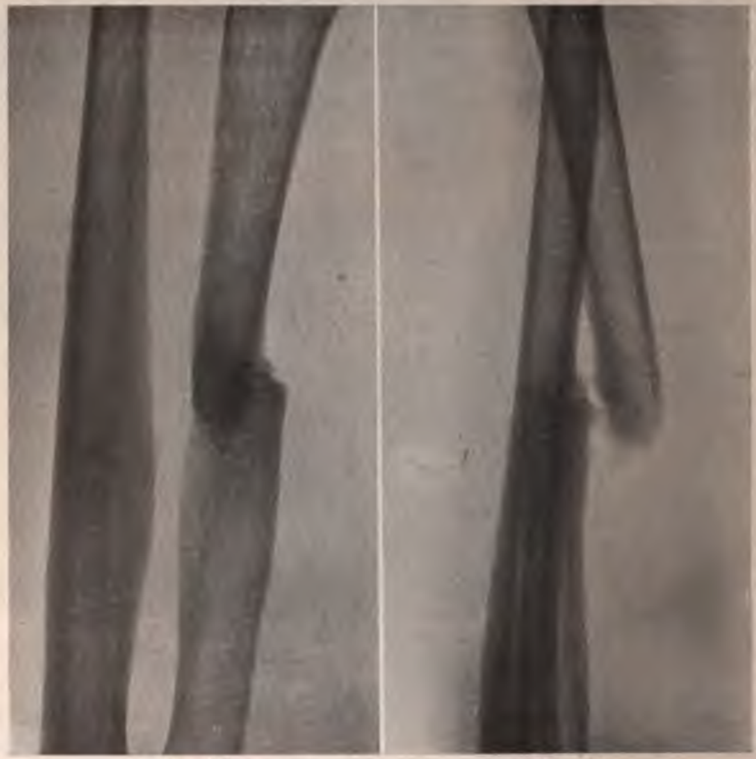


Fig. 815. Fig. 816.

Fig. 815.—Antero-posterior view of fracture of the radius.
Fig. 816.—Lateral view of same case.

The Röntgenogram (Fig. 814) produced is not a photograph; it is a record of the combined, superimposed images of the various densities contained in an almost infinite number of planes in the object examined, through which the ray has passed.

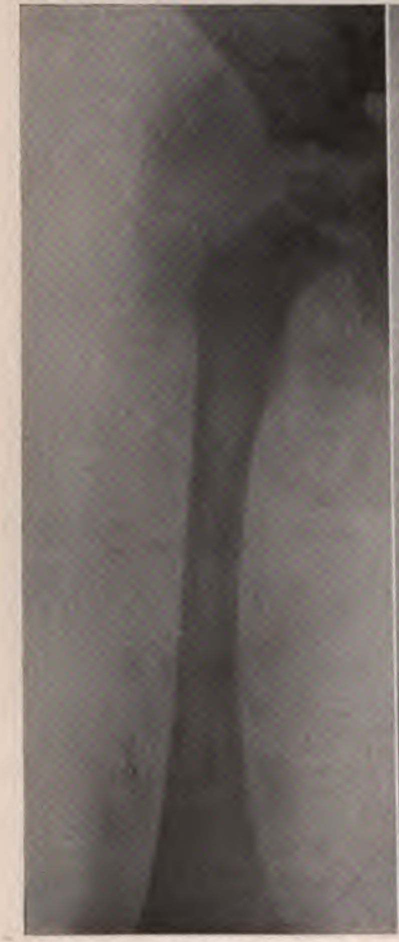


Fig. 817.

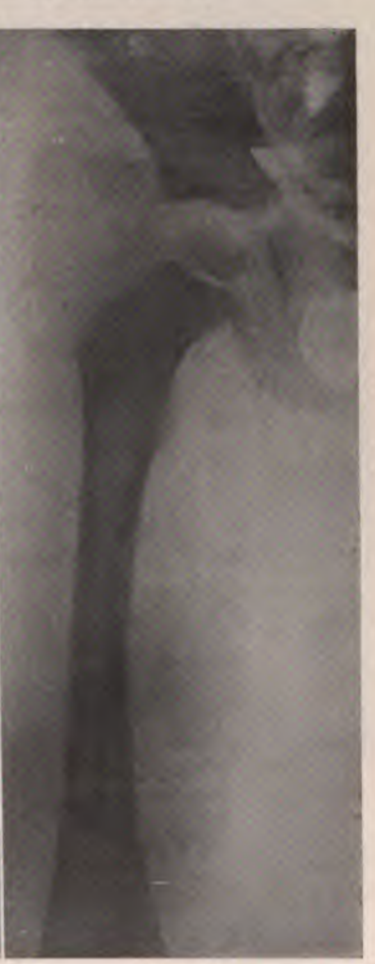


Fig. 818.

Fig. 817.—Fracture of the femoral shaft which cannot be detected because the rays do not pass through the plane of the fracture.

Fig. 818.—Another plate of the same case. No evidence of fracture.

A single view of a fractured bone is seldom or never sufficient for the diagnosis; exposures should be made from at least two points of view, generally at right angles to each other, and sometimes more are necessary to bring out obscure points, since the Röentgenogram is in a way a silhouette or shadow image.

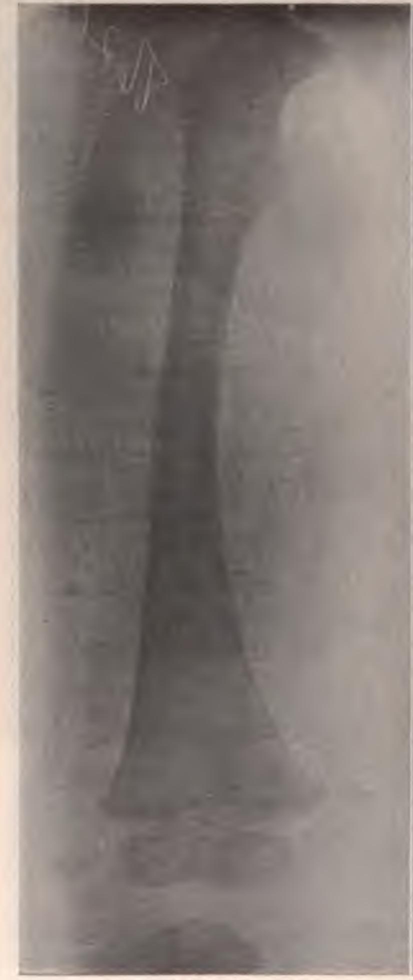


Fig. 819.

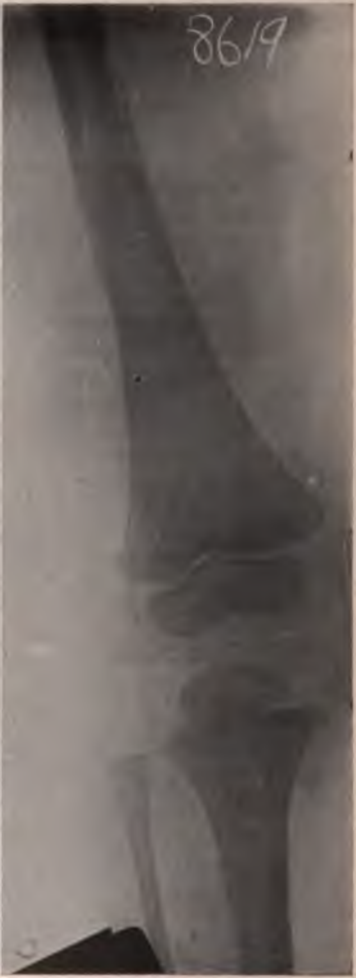


Fig. 820.

Fig. 819.—Another plate of the case shown in Figs. 817 and 818. The outlines seen in the middle of the shaft might lead one to suspect fracture but are hardly sufficient to establish a diagnosis.

Fig. 820.—Another view of the same case showing the fracture quite distinctly. This plate and Figs. 817, 818 and 819 demonstrate the possibility of overlooking a fracture if the case is examined only in one plane.

Fig. 815 shows an antero-posterior view of an old fracture of the radius; the lateral view shown in Fig. 816 demonstrates very strikingly the need of more than one view.

Figs. 817, 818, 819 and 820 are all views of the same femur (child) taken from different viewpoints.

In certain parts of the body (the shoulder, for example) it is impossible to obtain two views at right angles to each other; here the stereoscopic method is of special importance. In this method two views are made from slightly different viewpoints, but bearing a mathematical relation to each other. For the first view the target of the tube is placed one and one-quarter inches to one side of a perpendicular from the plate passing through the center of the object; the second plate is made after moving the target an equal distance to the other side of the perpendicular. Stereoscopic plates are observed by means of a plane prism stereoscope (not the usual parlor instrument), and a perspective view results, enabling one to get all the relations between the parts of the image (Figs. 821 and 822, subcoracoid dislocation of humerus). This stereoscopic view may be studied by means of a trick of visual accommodation if one has not a stereoscope handy; direct the gaze to a point midway between the two plates, then focus upon an imaginary object some distance beyond; this will cause the appearance of three images; study the middle one, disregarding the two outside.

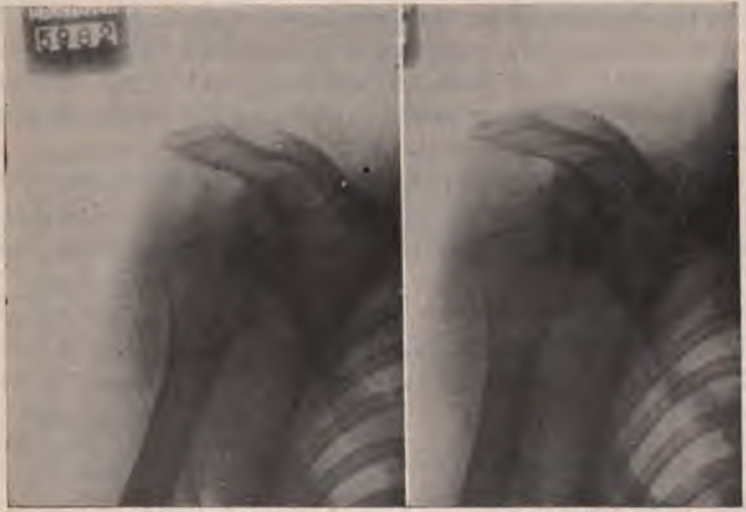


Fig. 821. Fig. 822.

Figs. 821 and 822.—Stereoscopic Röntgenogram of a low subcoracoid dislocation of the shoulder.

One should do his own developing, instead of referring it to a photographer; the photographer may be a better technician at the outset, but he is rarely sufficiently acquainted with anatomy and pathology so that he will know at what stage of development to arrest the process.

The dark-room must absolutely exclude all daylight or artificial light save that from the red lamp. The red light should be tested by exposing small plates to it and developing them, in order to make sure it is a "safe light." If possible it is well to begin the development of plate in total darkness. Put the plate, film up, in the tray and quickly swirl the developer over it, then continuously rock the tray, slowly; hold the plate up to the red light after a time, and from time to time, in order to observe the progress of development, but do not do this too often, no matter how "safe" the light is. Develop until by reflected red light the back of the plate shows some darkening, or until the image seen by red light transmitted through the plate, begins to fade.

A good developer is that known as the Cole developer, used by Dr. L. Gregory Cole of New York:

Distilled water	32 ounces
Metol	40 grains
Hydroquinone	6 drams
Sodium Sulphite (dry)	2 ounces
Sodium Carbonate (dry)	2 ounces
Potass. Bromide	40 to 60 grains

A fault of a good many developers recommended for Röntgen work is that they do not contain enough bromide.

The temperature of the developer should not be above sixty-five degrees Fahrenheit. After development, rinse the plate carefully for a real minute in running water, put it into one or another of the hyposulphite of soda fixing solutions in order to dissolve out the unexposed silver salt from the emulsion; after about twenty minutes, or at least ten minutes after the foggy white color has gone from the back of the plate, put it in running water for one hour; then take out and set on edge to dry in a room of even temperature, where dust will not fall upon the soft emulsion.

Be cleanly in the dark-room. Have trays for each special purpose, use them for no other, and keep them clean. Wear thin rubber gloves when developing; metol is very poisonous to the skin of some people. Rinse the hands carefully every time they have been near a solution. If a very little hypo is carried into your developer you will find your plates displaying some very peculiar appearances.

Plates which are not quite perfect in certain respects may be improved by intensification or reduction, as indicated by the quality of the density, but really in order to obtain a correct plate the exposure must have been very nearly correct in the first place; after-manipulations will not make a good plate out of a bad one.

In studying plates, put them in a window against a clear sky, north light preferred. A box fronted with ground glass and containing electric lamps is a convenience as it may be used at any time.

Make plenty of experimental plates of normal parts in order to have a standard. It is well, in injury cases, to examine the corresponding normal part until one becomes familiar with normal Röntgenologic anatomy, and has a collection of normal plates.

There are no "high lights" in Röntgenograms; these are important in camera photography; the corresponding condition in a Röntgenogram is the black part of the plate outside the field of the image; in Röntgenography we are dealing with what photographers call "shadow detail."

In studying plates, look out for the appearances (artefacts) caused by air bubbles adhering to the plate during development, finger marks, scratches, light-struck spots due to holes in the envelopes, and chemical stain and fog.

Look out for confusing lines where the shadows of two or more bones are superimposed.

Do not be deceived by the heavy (white) shadow of a ridge for muscular attachment, which at times may appear to be the margin of a fracture shadow.

Remember that epiphyses unite at varying periods in the development of the individual.

Do not mistake a normal center of ossification of a condyle for a displaced fragment of bone.

Remember that a patient may have more than one fracture.

Remember that a fracture may be located at some distance from the seat of pain.

Remember that a functionally perfect result may appear very far from being an anatomically perfect result.

Just because your plates show good apposition in a fracture located near a joint, do not be over-optimistic in your prognosis.

CHAPTER LIX.

THE OPEN TREATMENT OF FRACTURES.

The use of the X-ray and operative treatment have, of recent years, greatly improved the results in certain fractures and dislocations. Open treatment is particularly adapted to the correction of deformity in instances in which simpler methods cannot accomplish reduction or fail in preventing subsequent displacement during the after-treatment. Cases in which operation is performed may be divided into two groups: the first includes cases in which this method has been chosen soon after the injury because of the improved results which it may offer; the second includes cases which are operated upon as a last resort after non-operative methods have been tried and proven unsuccessful, or in which operation was demanded because the condition was compound from the first. The results of these two groups of cases are quite different and should not be confounded when deliberating upon the advantages of operative treatment. Consideration at this time is only given to cases in which operation is performed as an initial measure because it offers better results than non-operative procedures. Operation done in compound fractures will be taken up under the headings of "Treatment of Compound Fractures and Dislocations," page 789.

All forms of treatment give a higher proportion of functionally perfect results in children, and hence the difference between operative and non-operative results is less marked before puberty. With advancing years the proportion of cases in which a better result can be obtained by operation increases. Mechanical means for the direct or internal fixation of the fragments have been known and employed for many years, but it is only recently that improved technique, both as to appliance and asepsis, have demonstrated the real value of the operative method. Wire, nails, screws, pegs, clamps, ferrules, and absorbable suture materials, have all been used, and even now have their appropriate places. But the development of the Lane plate has proven, undoubtedly, the greatest stride in the open treatment of fractures. It is a well known fact that perfect anatomic reduction is not always essential to the complete restoration of function, yet the more cases in which absolutely exact reduction is obtained, the greater will be the decrease in the percentage of cases showing loss of function. We should, therefore, endeavor in each and every case to secure as accurate an anatomic result as is possible. Proper operative treatment not only accomplishes more perfect apposition and fixation of the fragments but shortens the period of disability, gives better functional results and lessens the suffering of the patient. *Probably the best time for operation is from seven to ten days following the accident.* This allows the tissues to recover from the initial shock and gives time for the development of local resistance. In operating on simple fractures the surgeon should fully appreciate that he is rendering the condition compound, and that infection following open treatment is often productive of much worse results than would be the case if surgical measures had not been instituted. For this reason the most strictly aseptic surroundings are demanded and the operator should be skilled in this particular branch of surgery. Those unaccustomed to bone work should not attempt these cases. The surgeon should possess a mechanical sense peculiar to this particular type of work, and an appreciation of the relative strengths of the materials operated upon and employed. This mechanical sense, referred to, is easier to illustrate than to define. For example: if we observe an experienced mechanic at work, we never see him tighten a nut until the threads strip or the shaft of the bolt twists in two, and yet he tightens nuts of all sizes and threads, each one requiring a different degree of force to properly seat it. In like manner the expert cabinet maker saws and shapes his wood to fit the desired places and yet a nail is never driven without due consideration for the strength and nature of the material through which it passes and the function which it is to perform, nor is a screw driven home so that the last turn strips the thread, breaks the shaft or causes the wood to split. On the other hand, if we watch the apprentice learning his trade, the lack of mechanical sense is apparent in the frequency with which he spoils materials and ruins his tools.

Any one who has seen the last screw of a Lane plate split the shaft of a bone, or a bone graft broken just as it is being brought into position will appreciate the value of this mechanical sense and see what can be learned by the surgeon from the artisan. One desirous of increasing his proficiency in this particular branch of surgery should obtain fresh bones from the butcher and then with chisel, saw, nail and screw determine to his own practical satisfaction the relative strength of bone, and just what it will, and will not stand. Later on fresh specimens from the dissecting room should be procured and the same experiments conducted. In addition the various types of fixation may be tried out on different portions of the bone and the security of the fixation tested. The difference between cancellous and compact tissue may be appreciated in this way and in no other, outside the operating room. When this experience has been gained further obstacles to progress may be minimized by assisting or observing some surgeon of experience in bone work, until a satisfactory technique is obtained.

The question of when, and when not to operate in a given case depends upon the general condition of the patient and the degree of reduction which is possible by non-operative methods. Diseased states, such as diabetes, erysipelas, advanced nephritis, etc., offer contraindications to operation, in the open treatment of fractures, the same as they do in other fields of surgery. If the general health of the patient allows of an operation, the question then arises: "Can an equally good result be obtained by the non-operative method as is possible with open treatment?" and secondly, "Are the proper surgical surroundings and skill available?"

In conclusion, then, we might state that with the proper health of the patient and available surgical facilities, all cases of fracture should be operated, in which an equally good result cannot otherwise be expected.

The site of the operation should be carefully shaved, and painted with a three and a half percent solution of iodine (half strength tr. iodi) the day preceding the operation. The parts are then covered with sterile dressings until the time of operation. The parts are again painted with tincture of iodine (five percent) before the incision is made. As soon as the skin is divided the cutaneous edges should be covered with gauze or towels which are secured in position by small tenaculæ, thus preventing infection of the deeper structures from the cut edges of the skin. Rubber gloves are demanded, the hands should be kept out of the wound, as far as possible, and instruments having come in contact with the gloves should not enter the wound. In other words, the most strict aseptic precautions should be observed in every detail, gloves should be worn and then, while operating, the surgeon should consider his gloved hands capable of infecting the wound. The danger in this particular work lies largely in the fact that a glove may be torn by one of the serrated fragments while attempting reduction, and when this occurs the pent-up perspiration from the hand is poured out into the wound. A pin-hole in the glove may cause leakage onto the field of operation during the entire procedure.

The details of the operation and the exact form of internal fixation which will best meet the requirements of the case in hand are often only determined after the bone has been exposed. The exact nature of the fracture, with the fragments exposed, frequently appears different from the conditions anticipated, even though careful examination has been previously made and the X-ray employed. The surgeon should, therefore, have a number of appliances ready that he may choose from among them to more perfectly meet the requirements of the conditions encountered. If an internal fixation appliance is employed it should secure the fragments as solidly as may be, even to the extent of sustaining the weight of the extremity. In the subsequent treatment, however, splints should be employed in such a manner as to relieve the internal fixation appliance from as much strain as possible. In other words, internal fixation should never be called upon to do the work of splints or other forms of external fixation. The fact that internal fixation is so often used in the open treatment of fractures does not necessarily indicate that the objects of operation may not sometimes be attained without its employment. In some instances accurate engagement of the serrated ends of the fragments during operation, will be sufficient to prevent lateral or overriding deformity, and the proper application of appropriate splints may be relied upon to prevent angular displacement. Reduction of deformity and fixation are thus obtained by operation, but without the use of any type of internal or direct fixation.

It is essential that the anatomy of the parts operated upon be understood so that important structures, such as nerves and vessels, may be avoided and the displacing action of the muscles attached to the fragments may be appreciated. The internal structure of the bone should be understood as well as its surface form, since so much depends on the nature of the portion of the bone operated.

Irrigation of the wound, just before closure, with a gallon or so of hot sterile physiological salt solution will promote hemostasis and tend to remove any infection which might have gained entrance during the operation. The use of the so-called antiseptic solutions within the wound are not only useless, but tend to damage the tissues. When possible a running suture of catgut should approximate the muscles before the skin is closed. Deep through and through sutures are most objectionable. The large majority of operations done on fractures pass through heavy muscular tissue which is highly vascular. Extravasation of blood into the wound is almost sure to follow, even though hemostasis seems perfect at the time of closure. Living blood within the vessels possesses distinct bactericidal activity, but when extravasated this quality soon disappears, the result being that collections of dead blood within a wound act as most excellent culture media, at body temperature, thus favoring subsequent suppuration. It is evident, therefore, that fluids forming within the wound following closure should be allowed to escape at the earliest possible moment. If a few strands of silkworm-gut be so placed within the wound that they act as drains, this most important requisite will have been fulfilled. The field of operation should be inspected within twenty-four or forty-eight hours and gentle pressure exerted in such a manner that any fluids which may have collected in the meantime will be expressed.

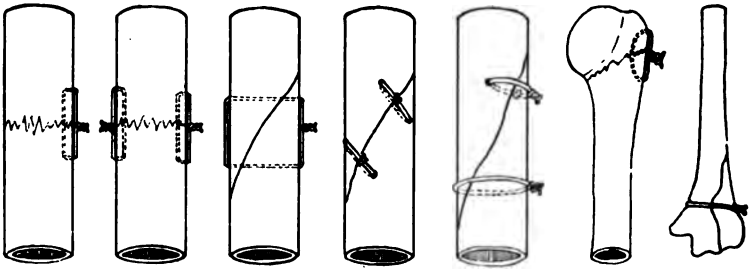


Fig. 823.—Methods of using wire in the internal fixation of fractures.

The Use of Wire has been largely supplanted by the Lane plate, though it still retains its place of preference in certain fractures, notably those of the olecranon and patella, and in some cases of fractures in the extremities of the long bones. The different ways in which wire may be used are shown in the accompanying plates (Fig. 823). In fractures near the expanded extremities of the long bones a single loop of wire properly placed may be sufficient to prevent displacement (see Fig. 825). In wiring the shafts of the long bones it is almost essential that two points of fixation be employed to secure proper leverage (see Fig. 638). The circular wire has the advantage of not entering the medullary cavity, and of not requiring the destruction of bone tissue by drilling. In most instances the firmest hold is obtained by having the wire pass perpendicularly through the plane of fracture whether spiral, oblique or transverse. If the fracture approaches the transverse type or the serrations are coarse enough to permit of firm engagement a single loop of wire may be sufficient to prevent lateral displacement, angular deformity being prevented by the proper use of splints.

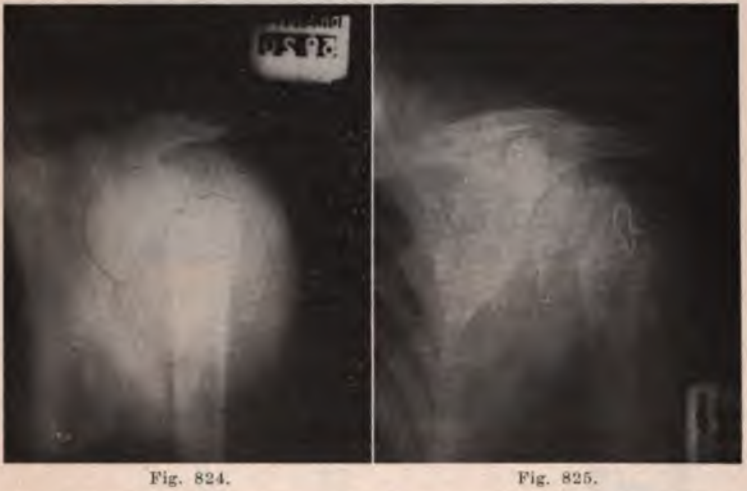


Fig. 824.

Fig. 825.

Figs. 824 and 825.—An example of how a single loop of wire can be made to hold the end of a bone in position.

The essentials in the use of wire are firstly, that the material be heavy enough to withstand the strain to which it is subjected, and secondly, that it be firmly placed and secure proper leverage on the fragments. These points are best appreciated by referring to the accompanying diagrams. Heavy wire is as well tolerated by the tissues as if the material used were light and inadequate. Virgin silver wire has for years been considered the best, but recently bronze-aluminum wire has been preferred by many, because of its greater torsion strength.

Nails, Pegs, Screws and Staples have all been used to secure the fragments in position, but at the present time the development of more perfect appliances has rendered their use more limited. They are only now employed for the purpose of securing a small, displaced fragment such as a fractured condyle, tubercle or tuberosity. A good example of the appropriate use of a nail is shown in Fig. 219. In this case the external condyle of the humerus was broken off and so displaced that the elbow would have remained useless if operation had not been performed. The nail has been driven at right angles to the displacing pull of the muscles attached

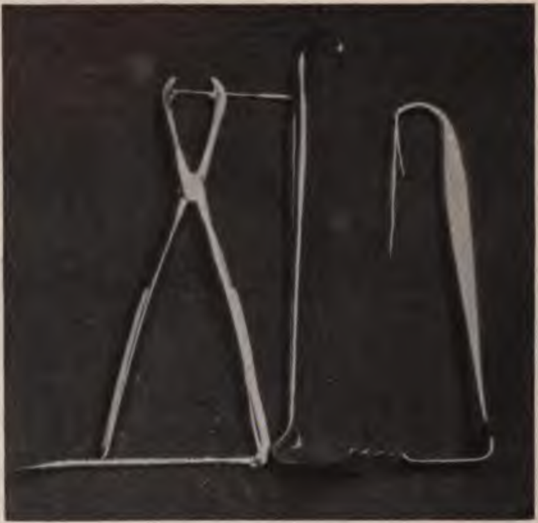


Fig. 826.—Instruments which have been found of considerable service in operating on fractures. On the left is shown a lion-jawed bone forceps with ratchet in the handle. By means of this instrument it is often possible to hold the fragments in reduction while applying internal fixation apparatus. The instruments to the right are ordinary retractors with the handle ends shaped and drilled so that they may be used in passing wire about the shafts of long bones.

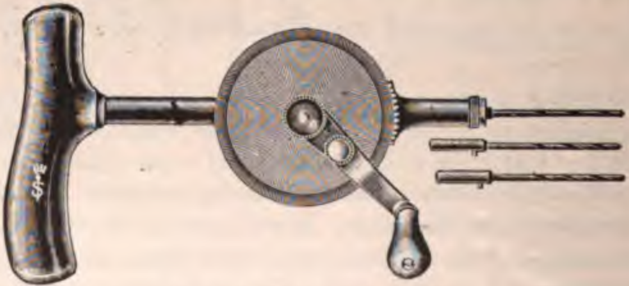


Fig. 827.—The Lane bone drill.

to the fragment, and in this position securely holds the condyle against the recurrence of deformity. In the use of nails the hole drilled in the bone should be only a trifle smaller than the size of the nail to be used, otherwise the bone may be split when the nail is driven home. The same holds true in the use of screws, pegs and staples.

Screws and nails have been used with some success in the treatment of fractures of the femoral neck, the nail or screw being driven through the great trochanter to enter the neck parallel to its long axis. The reason that success has not been more constant in operating on this portion of the femur is because of the soft, cancellous tissue of which the internal structure of the upper end of the femur is composed. Screws, nails and pegs depend for their hold mainly on compact tissue, and in regions of the skeleton in which cancellated structure predominates, little reliance can be placed upon them if the displacing action is considerable. Thus when a nail is driven into the extremity of one of the long bones it

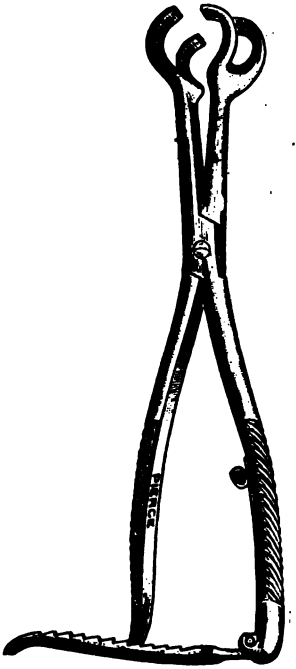


Fig. 828.—Bone forceps.

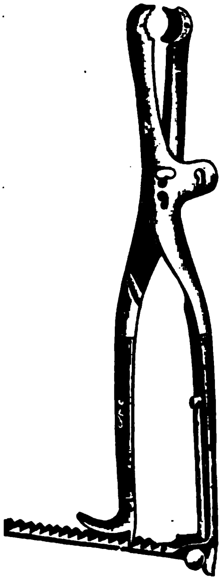


Fig. 829.—Bone forceps.

will usually be found possible to tear it out with the fingers; but if the shaft is selected as the site of the experiment the nail will be found as solidly seated as if driven into wood. This difference is entirely dependent upon the disposition of the compact tissue, and it is evident, therefore, that before a surgeon operates on a given region he should be acquainted with the internal structure as well as the surface form of the portion of the bone fractured. If a nail or screw once gives in cancellous tissue the security of fixation is lost, but on the other hand a loop of wire never releases the fragments until entirely torn out even though some displacement may occur. Screws, like nails, depend on the compact tissue for their hold, and it is apparent that their value decreases as the epiphyses are approached. The thread of any screw used in bone work should continue to the head and the screw itself should be of the type used in woodwork. Sherman has devised a screw of the machine type with a shaft of uniform thickness throughout. The end of the screw is made like a tap so that it cuts its own thread as

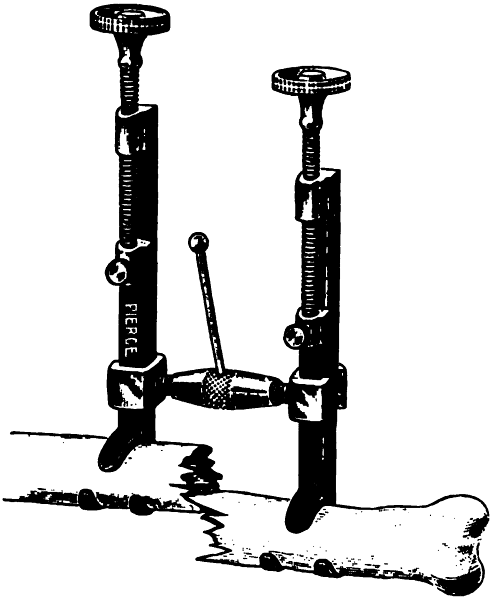


Fig. 830.—Gerster's turn-buckles for reducing difficult fractures, especially of the long, large bones such as the femur and humerus. They may be used to advantage in some cases though it is seldom that proper angulation of the fragments and manipulation fail in accomplishing reduction in the open method. Great force can be exerted by this mechanism and it should not be used without due regard for the damage it may inflict.

it sinks into the bone. The principle is good and the screw should be efficient, though the author has had no experience with it. When a screw is driven home it should not be too tightly fixed lest it strip the threads cut in the bone or cause the subsequent absorption of compact tissue through too great stress. Ivory pegs are practically unused at the present time. Nails and screws should be made of steel and either nickel or silver plated.

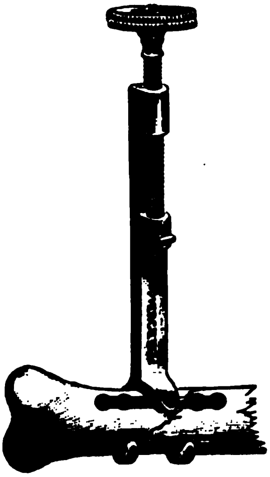


Fig. 831.—Appliance for holding plate in position while screws are being placed. It also holds fracture in reduction.

The Four-post Clamp.—Numerous modifications of the four-post clamp have been devised and used with more or less success though they have been almost entirely superseded, in the last few years, by the Lane plate. Notable among the variations of the four-post clamp is the one devised by Parkhill in which the fragments are held in alignment by four long, threaded, steel rods. These rods are screwed into drill holes, two on either side of the fracture, and held together at their superficial ends by a special locking device (see Figs. 832 and 833). The four posts must be in the same plane and parallel to each other in order that this particular locking device may securely hold them; it will readily be seen that this type of appliance is difficult of application.

Some other modifications of the four-post clamp do not require that all the posts should be parallel, although it is necessary in all types that they be in the same plane. Excellent results have been secured by using the four-post clamp, and it will be found at the present time the most satisfactory method, next to the Lane plate, of securing some forms of fracture. If the mechanics of the clamp be studied, and compared with the plate, its inferiority will be apparent. In tracing the fixation through the clamp from one fragment to the other it will be seen that there are twice as many points of possible motion as compared with the plate. Thus a four-post clamp has eight points of possible motion, whereas a four-screw plate has only four. In addition to this the four-post clamp is at a disadvantage because of the distance of the locking device from the bone, which means so much leverage against fixation. Besides the mechanical inferiority of the four-post clamp, it will be observed that four tracts must be left open from the bone to the skin when the posts are in position, which can only mean increased risk

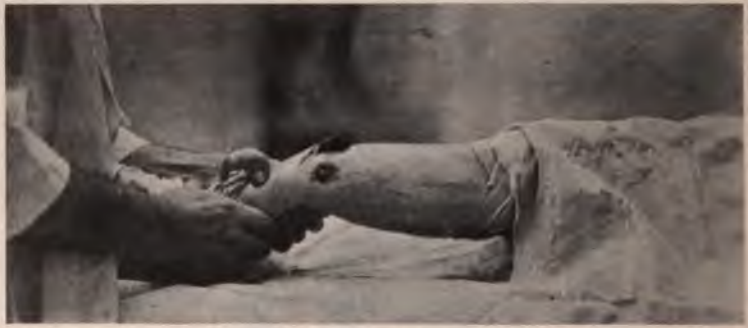


Fig. 832.—Shows a compound fracture of tibia and fibula. Note how the upper end of both lower fragments project through the skin. The angle at which the leg is held shows the flail-like condition. Picture taken a few hours following injury. Case seen with Drs. Lyman and Thompson.

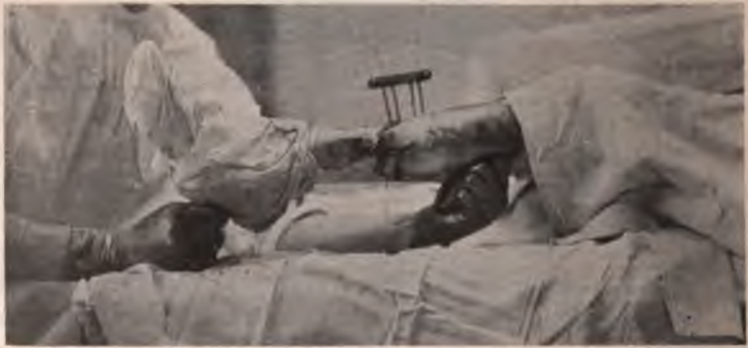


Fig. 833.—Same case as shown in Fig. 832 after reduction and securing of the fragments by means of Freeman's modification of the four-post clamp.

of infection during the after-treatment. It has been claimed by some that the four-post clamp possesses a distinct advantage in that no foreign body is ultimately left within the tissues. This argument may seem sound theoretically, but practice has proven beyond a doubt that certain foreign materials properly placed within the tissues are tolerated without the slightest disturbances. In the presence of infection all appliances are alike failures, whether four-post clamp, plate, nail, screw or wire. It will readily be seen, therefore, that the difficulty of application, mechanical in-

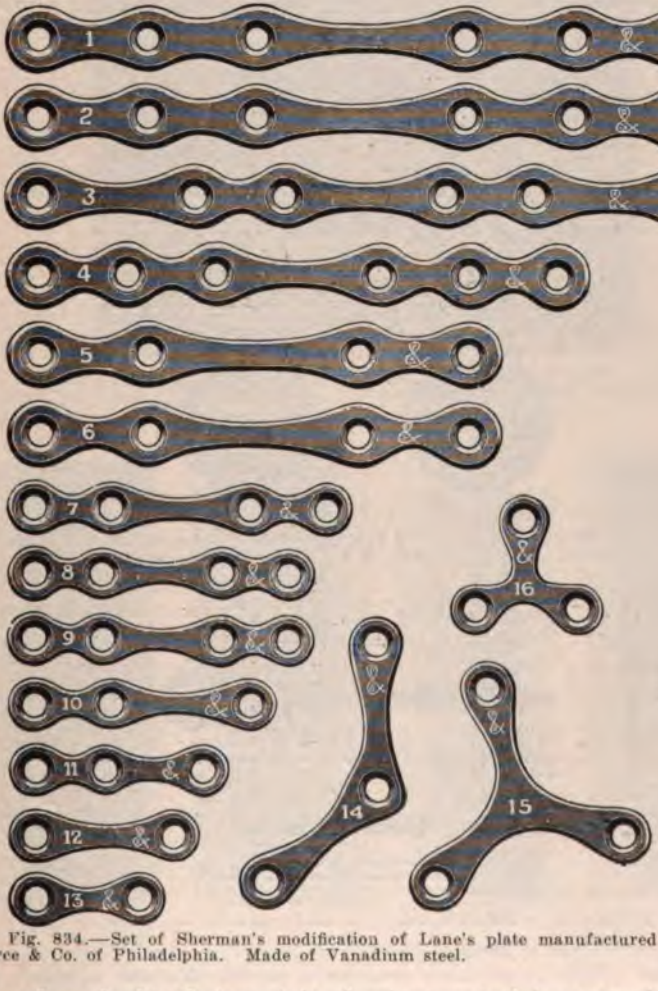


Fig. 834.—Set of Sherman's modification of Lane's plate manufactured by Harvey Pierce & Co. of Philadelphia. Made of Vanadium steel.

feriority and increased risk of infection render the four-post clamp a much more imperfect appliance than is the Lane plate.

The Lane Plate.—Lane's method of internal fixation of the fragments is accomplished by means of cold-rolled steel plates and screws as shown in Fig. 834. The most rigid asepsis is observed

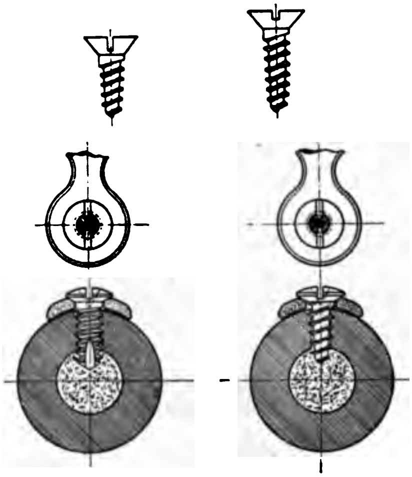
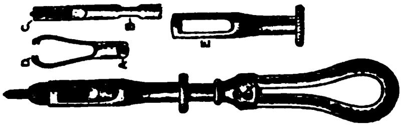
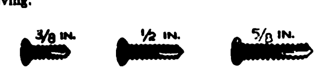


Fig. 835.—Comparison of the wood screw ordinarily used with the Lane plate, and Sherman's "tap-screw." (After Sherman in *Surg., Gynecol. & Obstet.*)



Screwdriver; special construction to fit tap screws. Center point fixes screw and insures vertical and direct driving.



Vanadium steel self-tapping (fluted) screws. Three flutes are provided at end of each screw, thus combining a tap and screw.

Fig. 836.—(After Sherman in *Surg., Gynecol. & Obstet.*)

during the entire procedure. As soon as the incision is made, the skin edges are protected and other precautions taken to prevent infection as previously described on page 756. The incision is carried down to the bone and the fragments exposed, brought back into alignment and held in apposition by means of a heavy clamp of special design. A plate of appropriate size is then placed and held against the bone by the clamp. Holes, slightly smaller than the screws to be used, are drilled in the bone corresponding in position to the openings in the plate. Screws are then driven home, securing the plate to the bone which in turn immobilizes the fragments. The deep structures are then approximated by catgut and the skin incision is closed. Drainage by means of silkworm-

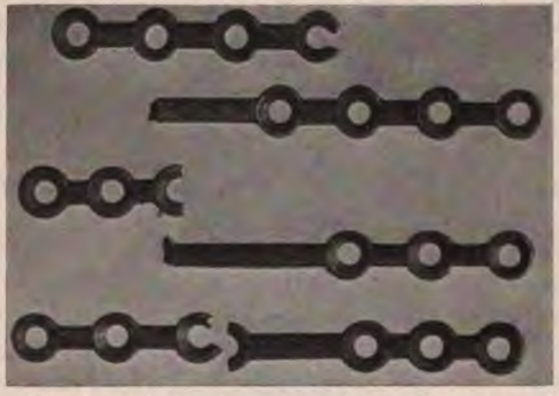


Fig. 837.—Examples of broken Lane plates of the ordinary type. Note the point at which the break usually takes place. (After Sherman in *Surg., Gynecol. & Obstet.*, June, 1912.)

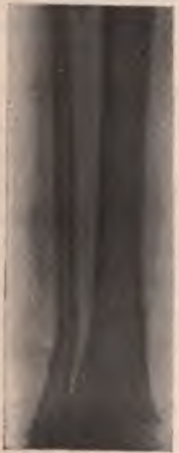


Fig. 838.

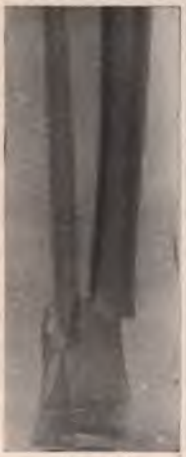


Fig. 839.

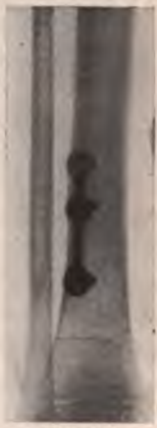


Fig. 840.

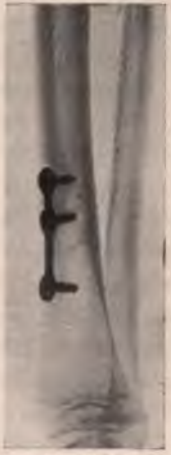


Fig. 841.

Fig. 838.—A. P. view of fracture of both bones of leg.
Fig. 839.—Lateral view of same case.
Fig. 840.—Same case two years later.
Fig. 841.—Another view of same case at time Fig. 840 was taken.

gut should be established for the first twenty-four or forty-eight hours to allow the escape of fluids which may collect within the wound. The plate should be accurately shaped to the surface of the bone before being screwed into position. It should be so bent as to come in contact with the bone throughout its entire extent without special stress at any given point. If the plate has been securely fixed and the proper aseptic precautions observed throughout the operation, it will remain in position indefinitely without giving rise to trouble. In the extremities of the long bones the plate is not as efficient because of the thinness of the compact tissue on which the screws depend for their holds. A simple wire loop, properly placed, will often hold the fractured extremity of one of the long bones in position more securely than the plate. The Lane plate should never cross an epiphyseal cartilage because of the possibility of disturbing the subsequent growth of the bone. A screw should never be placed closer than one-fourth of an inch from the end of a fragment; the nearer the screws are placed to the line of fracture the greater the danger of splitting the bone. Plates of various sizes, shapes and weights have been designed by Lane to meet the requirements in different portions of the skeleton and may be secured from the instrument dealer.

Absorbable Suture Material is employed and strongly advocated by some surgeons for certain fractures in which the displacing strain is not pronounced. Excellent results have followed its use in many cases, in other instances, however, the nature of the material has been responsible for a repetition of the operation because of the recurrence of deformity. The nature of the fixation required is so different from that to be fulfilled in the approximation of soft tissues that one should not employ absorbable material lightly and without due consideration for its shortcomings as well as its one advantage of being absorbable. It should be remembered that the most important time for fixation does not commence until eight or ten days after the operation when the bony callus begins to form. It is just about this time that absorbable material is beginning to lose its strength, and if it releases its hold within the first two or three weeks another operation may be necessary. The edges of the drill holes may cut the suture material before the callus is sufficiently strong to hold the fragments in position.

The so-called "ten day" and "twenty day" chromicized catgut does not always correspond to the label, in the time which it takes for the material to be removed by absorption. Ten to twenty days is more than ample for the processes of healing in soft tissues under aseptic conditions. Bone, however, requires a longer period in which to unite. If the suture material becomes soft and lax within a week or two, motion may occur between the fragments and delayed or non-union may follow. The surgeon, in the meantime, is laboring under the false impression that the fragments were securely and permanently fixed at the time of operation. In addi-

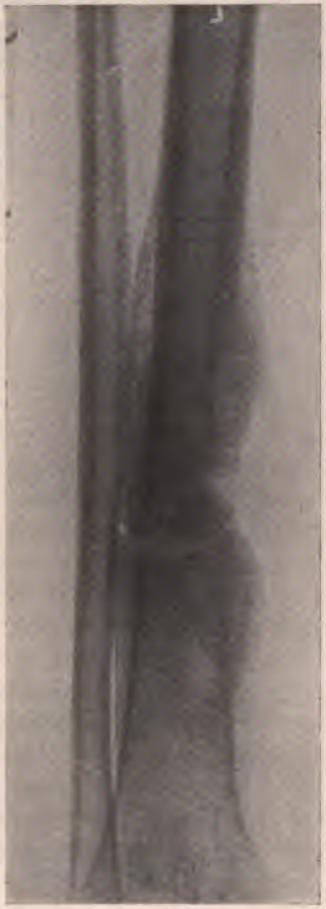


Fig. 842.—Tibia from which Lane plate has been removed because of infection. Non-union present in spite of heavy callus seen in plate. Note the absorption of bone where the screws were placed.

tion it might be stated that chromic gut is not as easy of sterilization as are metallic substances, such as wire, and the Lane plate. Absorbable suture material is more commonly used in repair of the patella and olecranon than in other regions. The purpose is accomplished in either of these two parts by suturing the torn fasciæ attached to the fragments rather than by direct suture of the bone.

In conclusion it might be stated that absorbable suture has the advantage of being entirely removed after it has accomplished its purpose, but it is so insecure that it had better be discarded, in most cases, in favor of some metallic, mechanical material.

The subject of the open treatment of fractures cannot be considered complete without entering into the uses and indications of bone transplantation. It is not improbable that many of the established methods in operating on fractures will, in the near future, be revised or even discarded when the possibilities and uses of bone grafting become better known and further developed. Bone transplantation will be taken up in the following chapter.

CHAPTER LX.

BONE TRANSPLANTATION.

One of the most important developments of surgery in recent years is the transplantation of bone to fill in deficiencies in the skeleton which have resulted from injury or disease. As a surgical procedure it has become well established in spite of the fact that the fundamental underlying principles are as yet by no means established. The three theories which have had the greatest following are those of Axhausen, Macewen and Murphy, and the very diversity of these theories points unmistakably to the fact that the subject has yet to be explored and the actual facts determined. Axhausen maintains that the bone composing the graft invariably dies, and is absorbed and replaced by new bone formed from the periosteum surrounding the transplant. According to this theory the periosteum is all that remains of the original transplant, and the success of the operation depends entirely on this membrane.

Macewen of Glasgow is of the opinion that the graft is reproduced entirely from the osteoblasts within the transplant, and that the periosteum has nothing to do with regeneration of bone, but acts only as a limiting membrane preventing the osteoblasts from penetrating the surrounding tissue.

Murphy of Chicago states that the graft acts only as a scaffolding for the production of new bone by the osteogenetic elements which pass from the living bone into the transplant at the points of contact. In other words, he maintains that the graft is not osteogenetic but only osteoconductive, and that therefore the solid contacting of the graft with living bone is the important point, and not the activity of the periosteum. It is probable that each of these theories contains some truth but that no one of them is entirely correct. Since the setting forth of these theories much experimental work has been done on the subject, and although much valuable, practical information has been gained in this way yet the ultimate fate of the graft has not been conclusively determined. From a practical standpoint we are not so much interested in the theories as we are in knowing the conditions under which bone may be successfully transplanted to fill in defects in the skeleton. Moreover it is not sufficient to know that under certain conditions the operation *may* be successfully performed but we must know just which methods will give the highest percentage of success, and just what conditions are most likely to interfere with the "taking" of the graft.

In order that we may develop the practical side of the subject we must examine into the results obtained in some of the more recent experimental work and consider these facts together with the theories just referred to and what we know of the embryonic development of bone and the repair of fractures. Following fracture certain tissues, as far as we can determine, resume their embryonic function and produce bone to repair the lesion. In the embryo the bone-forming tissues seem to be the periosteum and the osteoblast, but whether or not the bone-forming properties of the periosteum are inherent to this membrane or are dependent on the osteoblast cannot be stated. The bone cell is developed from the osteoblast, and in the presence of fracture it is not improbable that the bone cell reverts to its embryonic rôle and produces bone provided circulation is not destroyed. It would therefore seem that in the repair of a fracture ossification of the soft callus emanates from three sources: namely, the periosteum, the endosteum, and from the osteoblasts within the bone near the fractured surfaces of the fragments. If the bone-forming properties of the periosteum and endosteum depend on the osteoblasts then the process of ossification resolves itself into one word, viz., *osteoblast.* A transplant might be considered as an ordinary fragment if it were not for the fact that its circulation has been disturbed by being removed from its original position. This is a most important matter since the life of the bone cell, and hence of the bone itself, depends on an adequate circulation. It is an established fact that if a section of periosteum be stripped up from the bone and transplanted into other tissue (muscle for example), it is capable of living and producing bone. Now a normal bone receives its circulation from three sources: the periosteum, endosteum and the direct ramifications of the nutrient vessel or vessels. In removing a graft the branches of the nutrient artery are of course put out of function, but if the periosteum, when transplanted, can continue to live and reëstablish its circulation, it is capable, to a greater or less extent, of taking care of the attached bone and its contained bone cells. In considering the circulation of the graft and its periosteum it should be remembered that the function of circulation (namely, the supply of oxygen and nutrition and the removal of waste products) can, to some extent be directly accomplished by diffusion, osmosis, dialysis and infiltration within the fluids surrounding and pervading the transplant. A graft stripped of its periosteum may live, when transplanted, but the chances of its doing so are much less than when the membrane is left attached. A periosteum-free transplant is more likely to survive if broken up into small pieces, since the fluids thus obtain freer access to the bone cells. On the other hand it is well known that under favorable circumstances dead bone (sterilized by boiling and hence killed) has been successfully grafted into defects in the skeleton and what would seem still more remarkable inorganic materials, such as bars of magnesium, have been placed between the fragments and been replaced by strong living bone. The chances of transplanted bone living, whether periosteum-covered or not, are increased when it is firmly contacted with living bone. These facts would seem to indicate that Murphy's theory is correct, in as far as ossification may take place from osteogenetic elements passing from the ends of the fragments into the substance of the graft. Magnesium as a graft, however, has had only fair success even in regions of greatest vascularity, such as the face.

It would seem apparent therefore that the periosteum, endosteum and the osteoblast (whether situated in the graft or in the fragments) are each capable of producing bone under favorable circumstances and that therefore the technique most favorable to the activity of all of these elements, will show the highest percentage of success.

The transplant does not need to be as heavy as the section of bone which it is to replace. If the operation is successful and the transplant lives, it will increase in diameter until it is capable of properly withstanding the full strain to which the bone is normally subjected. This increase in size, however, is more or less dependent on the use of the member after the graft has solidly united. In other words, if the member into which the graft is placed is kept at rest and not subjected to strain after union of the transplant, the volume of the graft cannot be expected to increase in size to properly take up its function. This means, therefore, that after union has taken place the member should be *gradually* subjected to increasing strain until the transverse diameter of the graft has augmented sufficiently to take up its full function. The progress of this growth is best determined by Röntgenograms taken at intervals during the after-care of the case.

In obtaining a graft only a portion of the diameter of the shaft from which it is taken should be removed, since if a section of bone including the entire diameter with its periosteum is removed, repair of the defect with bony tissue cannot be expected. When a section of bone is taken from the tibia as shown in Figs. 846, 847 and 848, the space left in the crest of the shin is entirely repaired and filled in with living bone.

Experience has demonstrated that the procedure is most successful when the graft is taken from the same person. If this is not possible the nearest blood relative should be chosen. The prospect of failure is so great when the graft is taken from one of the lower animals that this source has been entirely discarded.

In order that we may arrive at a practical working knowledge of the subject we must review the established facts as determined by clinical experience and experimental work and apply them according to the principles of modern aseptic surgery, so that in a given case the most favorable conditions for the operation may be obtained. The most favorable conditions may be summed up as follows:

1. Absolute asepsis. The most rigid asepsis should be observed throughout, in exposing the fragments, in obtaining the graft and finally in placing it in position to fill in the defect. The graft should not come in contact with the gloved hand and the gloved hand should not be introduced within the wound if possible to avoid it. The subject of asepsis has been considered under the heading of "The Open Treatment of Fractures" (Chapter LIX, page 758). One should never attempt bone grafting in the presence of a discharging sinus or infection of any kind. After the sinus or diseased area has healed the operation may be attempted.
2. The use of an autoplastic periosteum-covered transplant.
3. The solid contacting of transplant with living bone; at both ends if possible.
4. It is essential that the transplant be covered with viable soft tissue. The thicker the edges of the incision the more soft tissue there will be to close over graft.

5. The avoidance, as far as possible, of non-absorbable material in fixing the graft in place. We cannot expect a graft to show as much resistance as is possessed by a fragment with intact circulation.

6. The graft should have a function to perform as previously explained. A graft will not develop or may even be absorbed if not subjected to some strain after union has taken place.

7. In obtaining the graft the entire diameter of a shaft should not, as a rule, be removed. It interferes with regeneration of the defect thus made.

Indications.—The conditions in which bone grafting is indicated are numerous and the future will probably disclose additional uses for this procedure. There are three classes of conditions which most frequently call for bone grafting.

1. To fill in defects in the skeleton.

2. To produce union between fragments where non-union has existed.

3. For the immobilization of joints and the support diseased parts.

1. The types of skeletal defects are numerous and are classified according to the etiologic element. They may be the result of congenital defects, destructive infections, tumor formations and trauma. From the standpoint of fractures and dislocations we are interested only in bony defects resulting from trauma. In severe compound comminuted fractures a large section of a bone, more commonly its shaft, may be destroyed and if the parts become infected (as they so frequently do, seeing that the injury is sustained under septic conditions) additional bony tissue may be destroyed. The end to be attained in such cases is to clear up the infection and obtain healing of the wound. If necrotic bone is present it should be removed. (See following chapter on the treatment of compound fractures and luxations.) When the parts are thoroughly healed an attempt should be made to fill the bony defect by bone grafting. The most satisfactory technique will usually be found to be the medullary graft or the inlay graft as described by Albee.

2. Non-union is a condition which in many cases can only be corrected by bone grafting. After non-union has existed for some time the ends of the fragments become sclerosed and often eburnated and seem to lose their power of forming bone or at least

are too dense to allow the penetration of bone-forming elements. Under such conditions bone grafting is the only way in which union can be obtained. The medullary and inlay grafts are the most satisfactory methods of transplanting bone to correct non-union. The inlay graft seems to be gaining favor over the medullary transplant in this type of work, although the technique is more difficult and requires more special apparatus.

3. For the purposes of support and arthrodesis bone transplantation is rarely called for in the treatment of fractures and dislocations. Instability of the knee joint following injury can, as a rule, be corrected by repair of the crucial and lateral ligaments.

Technique.—Bone grafting is by no means a new subject but it is only within the last few years that it has been widely employed and this is because of the improved results obtained by the more recent technique. It is apparent that in the evolution of a subject such as this a great variety of methods are evolved and discarded before a satisfactory technique is finally developed. A detailed description of some of the older methods, therefore, would be of interest from an historical standpoint only. Among those which have been most prominent might be mentioned the following:

1. The transplantation of living bone chips to fill in defects. As much of the periosteum as possible should be left attached to each chip. This method is deficient in that it does not afford fixation and the manner of contacting between the chips and fragments is more or less haphazard. The failures accompanying this method are much greater than when more recent technique (to be discussed later) is employed. It is now obsolete.

2. The transplantation of dead bone, either as chips or in one large fragment. This method does not give as high a percentage of success as the transplanting of living bone chips and is not employed at the present time.

3. The transplantation of bone or periosteum by means of the flap method in which the graft is raised from one region, turned on its pedicle and inserted into the bone in which the defect is to be filled in. This technique is difficult, limited in application and shows no advantage over the use of the free, periosteum-covered transplant. It is for the most part discarded at the present time although there are certain conditions in which it may be used to advantage. Prominent among these is the filling in of defects in the tibia by using the fibula of the same leg and in filling in

defects in one of the bones of the forearm by a graft taken from the other bone. This will be discussed later under "Regional Technique."

4. The grafting of foreign materials into defects. Some remarkable work has been done along these lines. Magnesium has been grafted into the defect and been absorbed and replaced by living bone. A silver framework has been made to replace a large section of the lower jaw and after being placed in position has been surrounded by bone, but such a result cannot be expected in any but the most vascular regions such as the face and even then failure is likely to result. Absorbable and non-absorbable materials have been discarded in favor of the living periosteum-covered transplant.

We are warranted in employing only the methods which are known to produce the highest percentage of success. At the present time the transplantation of a large, free, periosteum-covered transplant is the method which produces the best results. The manner in which this may be accomplished has varied in the hands of different surgeons and according to the region involved. The technique of modern bone transplantation in the treatment of fractures may be considered under the following headings:

1. The medullary graft or dowel method.
2. The inlay graft.
3. Regional or special technique in which the procedure is adapted to certain regions.

1. *The Medullary Graft or Dowel Method.*—It would seem unnecessary to repeat that first class operating room facilities should be available and that the surgeon be experienced in bone work. These conditions and the observance of the most rigid asepsis are essential.

The fragments are exposed and the ends freshened with saw, chisel, burr, gigli saw or motor saw according to the preference of the surgeon. The older the fracture the more important is this freshening of the ends of the fragments. If the ends are much sclerosed it may be advisable to remove considerable bony tissue. If overriding deformity exists it should be corrected, when possible, by traction on the limb. In old cases it may be impossible to bring the member back to its original length and in such instances enough bone should be removed from the ends of the fragments

to allow the overridden fragments to be brought back into alignment. The medullary cavity of each fragment is then reamed out with a burr or drill to receive the ends of the transplant. Murphy has devised special burrs for this purpose but the author has found

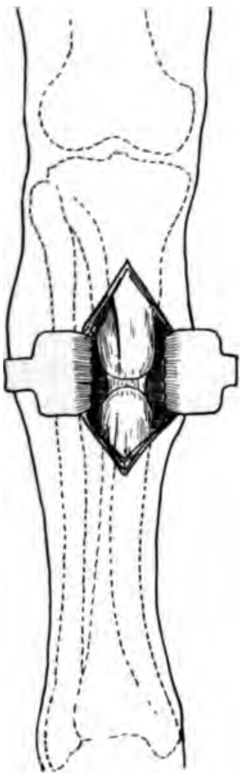


Fig. 843.

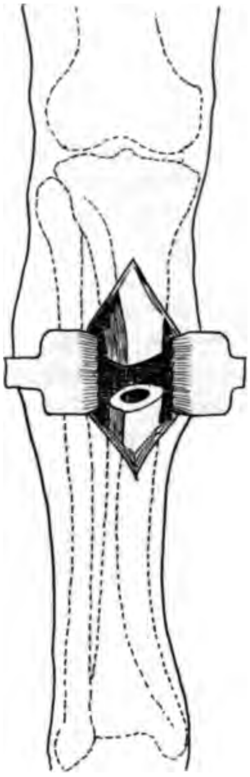


Fig. 844.

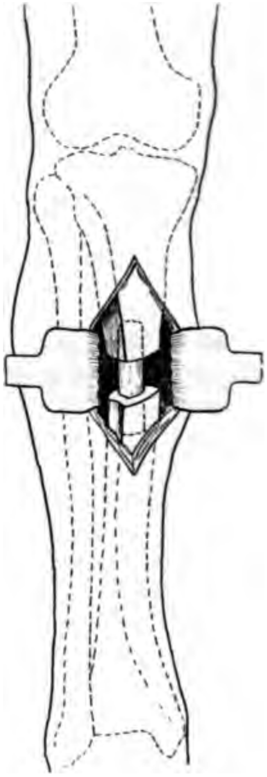


Fig. 845.

Fig. 843.—Old ununited fracture of tibial shaft with rounding of ends of fragments and interposition of fibrous tissue.

Fig. 844.—Same, after ends of fragments are squared off and medullary cavity in fragments reamed out to receive the graft.

Fig. 845.—Same, after medullary dowel graft has been placed in position.

that the work may be quite satisfactorily done with an ordinary machinist's breast drill.

The wound is then lightly packed with gauze, which has been wrung out of physiologic salt solution, and is thus protected while the graft is being obtained. The graft may be taken from the fibula, crest of ilium, upper third of posterior border of ulna, clavicle, etc., but the crest of the tibia is the favorite site and unless there is some special contraindication the transplant should be taken from this bone. The tibia is exposed and the tibialis anticus

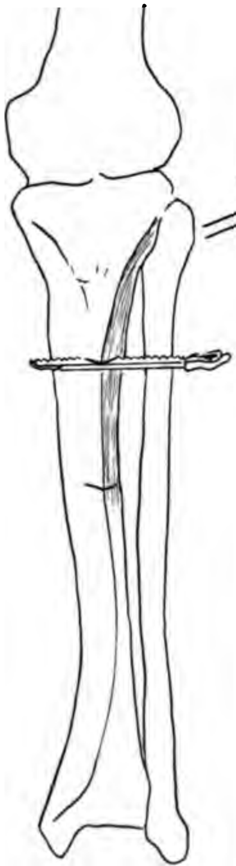


Fig. 846.

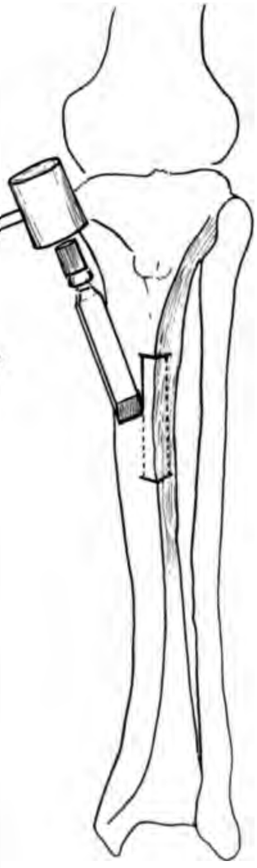


Fig. 847.

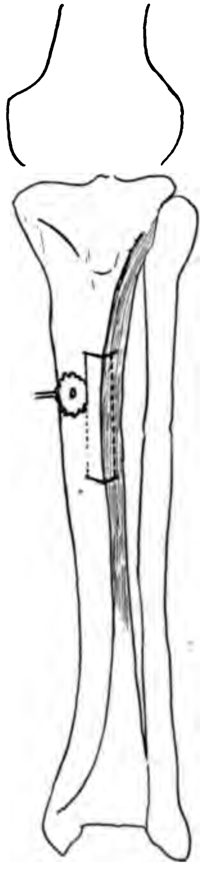


Fig. 848.

Fig. 846.—Making saw cuts in obtaining medullary graft. The distance between the saw cuts represents the length of the desired graft.

Fig. 847.—Removing medullary graft with chisel. Grooves are cut with the chisel and deepened until the medullary cavity is entered. The grooves should be deeply cut before an attempt is made to remove the graft, as otherwise it may be split.

Fig. 848.—Removing medullary graft with rotary motor saw. (See Fig. 851.) The saw should be kept under a stream of sterile salt solution to prevent heating and devitalization of bone tissue.

cut away from that portion of the external surface which is to be included in the graft. Two transverse saw cuts are made in the crest of the bone, the distance between them being the length of the desired graft. (See Fig. 846.) Mechanic's dividers or calipers are serviceable in transferring the measurement from the injured member to the site from which the graft is to be taken. The graft should be long enough to bridge the defect and extend into the medullary cavity of each fragment sufficiently to obtain proper leverage. Two grooves are next made on either side of the crest of the tibia and approximately parallel to it. The ends of the saw cuts are thus connected. A carpenter's chisel (without the wooden handle) makes a very satisfactory instrument for cutting these grooves as shown in Fig. 847. Care should be exercised in making these grooves, not to split the graft; they should be deeply cut before an attempt is made to drive the chisel into the medullary cavity and thus raise the graft and separate it from the rest of the bone. The graft should be about the size of the index finger if it is to be transplanted into one of the larger bones, and correspondingly smaller if it is to be used in one of the smaller long bones. The graft thus removed is trihedral, two of its sides are covered with periosteum while the third corresponds to the medullary cavity and is covered with endosteum. The ends are then cut with bone cutting forceps so that they will be slightly tapered, thus facilitating their introduction into the medullary cavities of the fragments and insuring a good fit and solid contacting between the graft and the fragments. The transplant should be handled only with instruments and should be shaped and placed in position as rapidly as possible. Washing the graft in salt solution is not advisable. After the graft is removed the wound made in securing it is lightly packed with moist gauze, and after the ends have been shaped one end of the transplant is driven into the reamed out medullary cavity of one of the fragments until solidly seated. The opposite end is then driven into the medullary cavity of the other fragment. When seated the graft should afford considerable support to the extremity. If the operation is done because of non-union and there is very little loss of bony tissue the fragments may come in contact over the graft and entirely cover it. If, however, grafting is indicated because of loss of tissue in a shaft as well as non-union, it will be best to shape the graft so that the fragments will solidly engage with it before they come together. (See Fig. 845.) The graft is thus made to bridge the defect and overcome shortening of the member. If the shaping of the graft is not carefully done one or both ends may slip into the medullary cavity further than desired and afford only a loose seating and allow shortening of the bone. This trouble can be corrected, to some extent, by using nails, pegs, sutures, etc., but there is nothing which will take the place of a solid contacting at the proper points. If the graft enters a fragment too far a hole may be drilled transversely through the fragment and graft, and a nail driven in place thus holding the graft in the desired position. Instead of the nail a heavy strand of kangaroo tendon may be passed through the hole and tied about the end of the fragment. What will answer the purpose still better, especially if Albee's doweling machine is at hand, will be to secure additional bone from the site from which the graft was taken and make from it a peg of bone of proper size to be driven into the hole passing through the end of the fragment and transplant. Foreign material, especially that which is non-absorbable, should be avoided as far as possible in fixing the graft in position since the resistance of the transplant is lessened by the circulatory disturbance resulting from its removal. Excellent results have been obtained even when the ends of the graft have been secured in position by nails or wire but, as previously stated in this chapter, it is incumbent on us to follow the methods affording the highest percentage of success and the use of foreign non-absorbable materials in fixing the graft is more likely to be followed by trouble or failure than when such material is not employed. In obtaining the graft the work may be a little more rapidly and neatly done if a circular motor driven saw is used.

In instances in which there is considerable loss of bone and the graft must be depended upon to maintain the length of the member without the ends of the fragments coming in contact, the medullary graft is probably superior to other methods. Where there is not great loss of bony tissue and the element of non-union is the important factor better results are claimed for the inlay graft.

2. *The Inlay Graft.*—(Albee's technique.) The fragments are exposed and the ends freshened as already described in preparing the fragments for the medullary graft. It is an extremely difficult matter to carry out this technique without the twin motor saw as used by Albee and if such is not available one had better employ the medullary graft.

A longitudinal incision is made through the periosteum and the edges turned back to expose the cortex of the bone in which the gutter is to be cut to receive the graft. Two longitudinal parallel saw cuts are made with the twin saws across the plane of fracture and extending into each fragment for a distance of two and a half to three inches. These cuts pass through the cortex into the medullary cavity of the fragments. Care should be exercised in using the saws to see that they follow straight lines as otherwise the gutter will show a lateral curvature which will be difficult to fit with the graft. Albee advises that the saws be adjusted to a distance of $\frac{5}{16}$ to $\frac{8}{16}$ of an inch from each other according to the size of the bone operated upon. In cutting the groove the saws should be kept under a stream of salt solution to prevent heating of the bone which tends to devitalize it. The bone is finally removed from the groove by cutting the ends with a small osteotome so as to make a tongue and groove. (See Fig. 849.) Either two

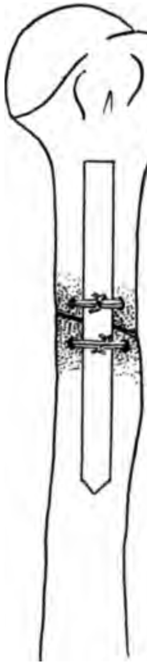


Fig. 849.

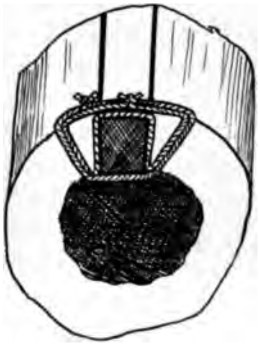


Fig. 850.

Fig. 849.—Inlay graft in place. Albee's technique in cases of non-union. The twin motor saws are almost essential in cutting the gutter to receive the graft and in obtaining the graft from the tibia.

Fig. 850.—Method of securing inlay graft in place with kangaroo tendon as advocated by Albee.

or four holes (according to the needs of the case) are then diagonally drilled through the cortex on both sides of the groove and in both fragments. These holes are drilled in pairs opposite each other, as shown in Fig. 849, and through each pair of holes is passed a double strand of heavy kangaroo tendon. The fragments are now ready for the graft. The wound is then lightly packed with moist gauze and the surgeon turns his attention to securing the graft to fill the gutter.

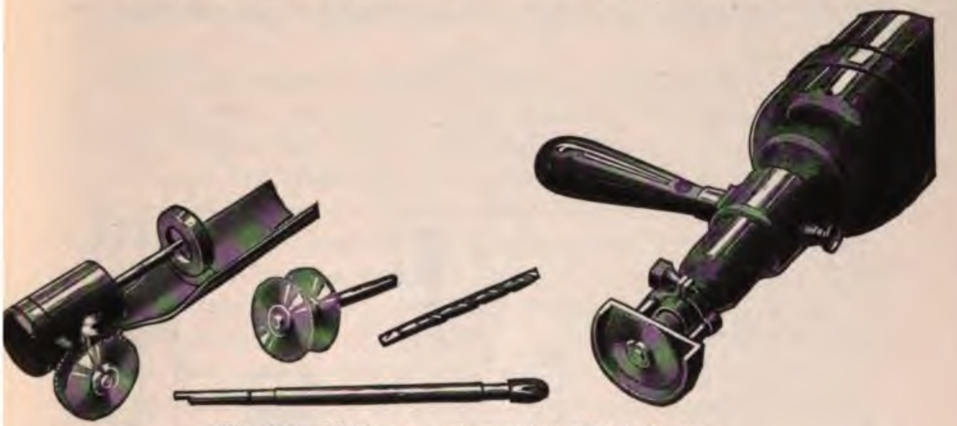


Fig. 851.—Motor saw equipment including twin saws.

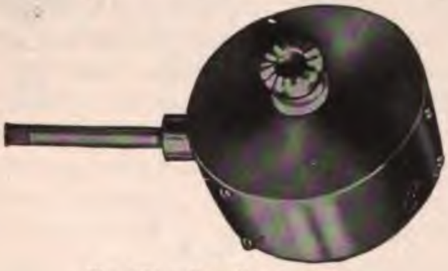


Fig. 852.—Doweling machine.

The internal surface of the tibia is next exposed and the dimensions of the desired graft are mapped out on the periosteum with a scalpel. The twin saws are then employed (without changing their adjustment) and a strip of bone, the same size as the gutter prepared in the fragments, is removed. The ends of this graft are then pointed with the saw to conform to the ends of the groove in the fragments. The graft is next transferred and the wound filled with a moist pack. One strand of kangaroo tendon is then pulled up from the medullary cavity between each pair of holes previously drilled in the fragments and the graft placed under these raised strands. The ends of the sutures projecting from the drill holes are tied and the graft thus secured in place. (See **Figs.** 849 and 850.) The tongue and groove effect at the ends of the graft causes the ends of the transplant to become firmly engaged when extension is removed and the muscles of the extremity contact, while the kangaroo tendon sutures maintain the fragments and graft in alignment. The older the case of non-union and the more sclerosed or eburnated the ends of the fragments, the longer the graft should be, thus insuring bone-forming activity by extending well into the substance of each fragment. It is claimed that this method gives better results in old cases of non-union because

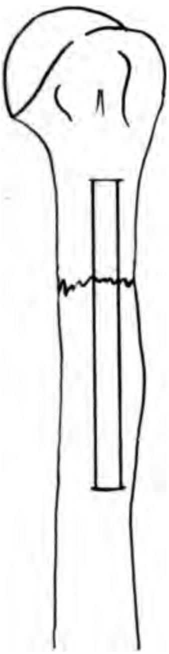


Fig. 853.

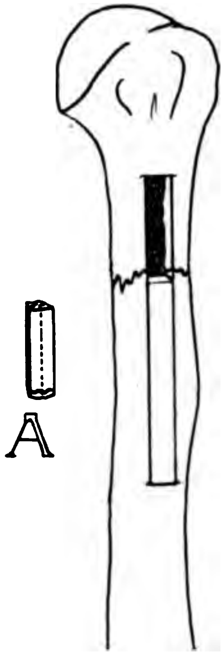


Fig. 854.

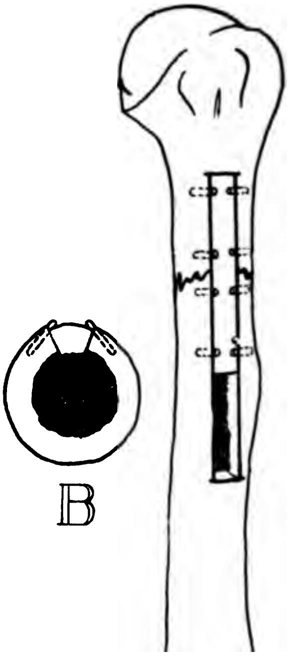


Fig. 855.

Fig. 853.—First step in Albee's technique in recent fractures. Superficial cuts are made with the twin saws and then each cut is finished with a single rotary saw so that the section of bone removed will be wedge-shaped.

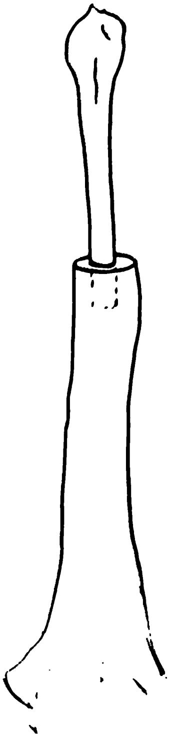
Fig. 854.—Second step. Short piece is removed to be cut up longitudinally to be used in making bone pegs with the doweling machine. *A*. shows short piece removed.

Fig. 855.—Third step. Long piece has been slid to opposite end of gutter so that it crosses the line of fracture and is held in place by means of obliquely driven bone pegs. *B*. is a cross-section showing manner in which oblique pegs hold graft.

of the greater surface of contact between graft and fragments. On the other hand it is certain that the inlay graft does not occupy as good a position from a mechanical standpoint as does the medullary transplant, and when heavy muscular contraction and shortening are to be overcome (as in fracture of the femur) the latter will be found the safer technique. It is probably not wise to attempt the inlay method unless the motor saw equipment is available.

Albee's Technique in Recent Fracture.—Albee employs a modified inlay graft in the operative treatment of recent fractures. The twin motor saw and the doweling machine are essential to this technique. The fragments are exposed and approximated. With the twin motor saw (the blades being adjusted to about $\frac{7}{16}$ of an inch apart) two longitudinal superficial cuts are made crossing the line of fracture as shown in Fig. 853. The saws should follow straight lines and the cuts should extend about twice as far on one side of the plane of fracture as on the other. A single motor saw is then used to complete the cuts into the medullary cavity. The cuts are not made in parallel planes but are so placed that the periosteal surface of the graft is about one-fourth of an inch wider than is the endosteal surface. Thus by making a wedge of the graft it will be impossible for it to be displaced into the medullary cavity. The short piece of the graft is removed and the long piece slipped to the opposite end of the groove so that it crosses the line of fracture. (Fig. 855.) The short piece of the graft is then cut up with the motor saw and converted into pegs with the doweling machine. Oblique holes are next drilled into the fragments on each side of the graft and the bone pegs driven home so that their ends project over the graft. (See Fig. 855.) Good fixation is thus afforded if the technique is properly carried out and the great claim for this method is that no foreign material is left imbedded in the wound. Albee recommends this method as a substitute for the Lane plate.

3. *Regional or Special Technique.*—The methods just described will meet the indications in practically all of the fracture cases in which bone grafting is indicated. The various modifications which have been employed in different regions of the skeleton have in almost all cases been devised to correct conditions resulting from disease or defective development, and hence cannot be properly considered as coming within the scope of this work. If the sur-



[illegible] upper [illegible] replaced by [illegible] of upper [illegible] of fibula. Seldom called for in the treatment of fractures but illustrates one of the adaptations of bone grafting.

geon appreciates the principles involved in bone grafting and the technique of the dowel and inlay grafts he will be able to modify his technique to meet the exceptional case. Some of the more common variations may be mentioned. The entire upper end of the humerus has been replaced with the upper end of the fibula. A longitudinal incision exposes the region previously occupied by the upper end of the humerus. The end of the fragment is freshened and its medullary cavity reamed out. The upper end of the fibula is next exposed and the length of the desired graft marked on its shaft. It is then cut across and the cut end inserted into the reamed out medullary cavity of the humerus while the ligaments and muscles of the shoulder are sutured about the upper end of the bone when placed in the glenoid cavity. In a similar manner the lower end of the radius has been replaced by transplanting the upper end of the fibula. The shaft of the tibia may be replaced by the shaft of the fibula without completely detaching the fibular shaft from its surrounding soft tissue. The operation is usually done in two stages though it may be done in one. The lower end of the upper tibial fragment is exposed, the end freshened and the medullary cavity reamed out. The upper end of the fibula is then divided and carried across to be inserted into the upper tibial fragment and the wound closed. The second step of the operation consists in transplanting the lower divided end of the fibula into the lower tibial fragment. The entire tibia has been replaced in congenital absence of this bone by using the fibula. The upper end of the fibula is placed against the femoral condyles while the lower end of the bone is placed against the astragalus. In loss of bony tissue in one of the bones of the forearm (e.g., the shaft of the radius) a section of the shaft has been raised from the ulna and grafted into the radial defect without severing the pedicle attached to the transplant. In an operation of this kind only a portion of the shaft of the ulna should be removed. In old ununited fracture of the neck of the femur excellent results have been obtained by driving a graft taken from the tibial crest through the trochanter and neck of the bone. The principles involved are the same as described in

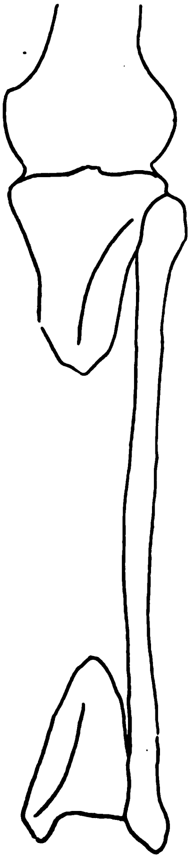


Fig. 857.

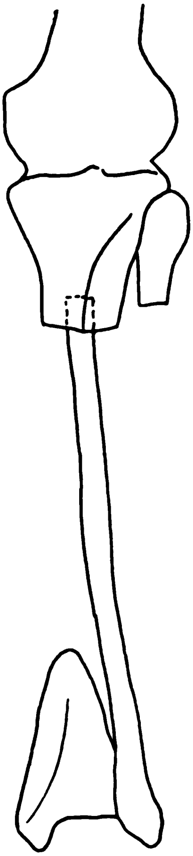


Fig. 858.

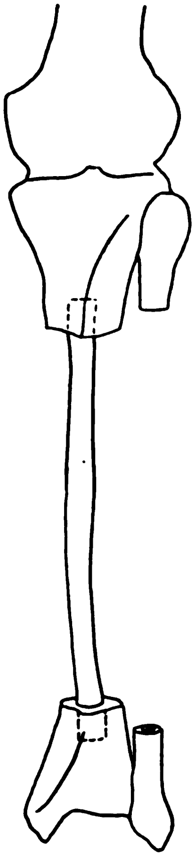


Fig. 859.

Fig. 857.—Loss of tibial shaft.

Fig. 858.—First step in replacing tibial shaft by shaft of fibula. The fibular shaft is divided and implanted into the upper tibial fragment.

Fig. 859.—Completion of operation. The lower end of fibular shaft has been implanted into lower tibial fragment.

the "Operative Treatment" of "Fractures of the Upper End of the Femur" (page 550), except that a graft is used instead of a screw or "screw-plate." The knee has been replaced by the same joint taken from a freshly amputated leg and the metatarso-phalangeal joint has been excised and grafted into an ankylosed elbow of the same patient.

It is manifestly impracticable at the present time to enter into all the possible variations of bone grafting and a consideration of the conditions in which it may be indicated. If the principles of this procedure are understood and the conditions under which it is most likely to be successful are fully appreciated the surgeon's mechanical sense and ingenuity should be sufficient to enable him to modify his technique to meet the requirements in a given case of exceptional needs.

CHAPTER LXI.

TREATMENT OF COMPOUND FRACTURES AND DISLOCATIONS.

The advent of asepsis and the improved technique of recent years has greatly reduced the percentage of bad results, previously so high, following compound fractures and luxations. Compound fractures are common, but it is unusual to see a dislocation which exposes the joint except in luxations of the fingers. The more common luxations are almost invariably closed.

The principles involved in treatment are practically the same whether the condition be a fracture or dislocation, and accordingly the two conditions will be considered together. Immediate reduction is the natural tendency as soon as the case is seen but in many instances nothing more detrimental could be done. The exposed fragment or articular surface must be considered infected, and if immediately replaced is almost sure to be followed by suppuration of the tissues with which it has come in contact. Many compound fractures and dislocations are produced by penetration from without, and in these cases we do not have to deal with a projecting fragment or articular end.

When a compound fracture or luxation is first seen the wound should be covered with a sterile dressing and the patient removed to surroundings in which proper surgical procedures can be carried out. Sterile surgical dressings may not be at hand, in some instances, and in lieu of these a towel fresh from the laundry is a safe substitute to use in covering the wound. The heat of ironing sterilizes the towel fairly well, especially as done in the modern steam laundry, and if the towel is unfolded so that a fresh surface comes in contact with the wound there will be little danger of infection from the dressing, and the wound will be properly protected during transportation.

An anesthetic is advisable in most cases. With the patient in the operating room the dressings are removed and the skin surrounding the wound painted with a five percent tincture of iodine. The edges of the wound are then inspected, and if lacerated and devitalized tissue is present it should be trimmed away until the margins present healthy viable tissue. If a fragment or the articular end of a bone projects through the wound it should be thoroughly washed with sterile physiologic salt solution until all foreign material has been removed. A few gallons of salt solution are not too much. The usual fault lies in too little washing. After the projecting bone has been thoroughly cleaned reduction is effected and the wound again washed with a few gallons of sterile salt solution. Internal fixation of the fragments should not be done at this time. Foreign materials should not be employed to secure fixation unless one is sure of asepsis within the wound, and in compound fractures the surgeon can never be sure of this point. It is often possible to obtain a solid engagement of the serrated ends of the fragments so that the deformity does not recur when proper splints are applied. When, however, the fragments cannot be held in good reduction it is better to close the wound, obtain healing of the soft tissues and perform a secondary operation at a later date, when the danger of infection has passed. In favorable cases the wound will be healed within a week or ten days and the surgeon may then expose the fragments by incision and employ internal fixation as already described in the "Operative Treatment of Fractures" on page 758.

In cases in which suppuration follows, internal fixation can accomplish no good and is capable of doing considerable harm. There is nothing lost, therefore, when internal fixation is not employed at the first operation even in the presence of recurrent deformity.

The essentials in the operative treatment of compound fractures and dislocations are the thorough and free washing of the wound and the trimming away of lacerated and devitalized tissue. The living tissues possess a certain amount of resistance to infection which increases during the first few days following the injury, but devitalized tissue and collections of dead blood within the wound possess no such resistance but act only as culture media for the development of the slight infection which remains even after the most painstaking attempt at removal and cleansing. The use of antiseptics within the wound, such as solutions of bichlorid of mercury, are not only useless but actually harmful. They not only have little influence on the bacteria but materially reduce the resistance of the tissues.

By careful attention to these two points (washing and removal of devitalized tissue) the proportion of cases in which suppuration follows in compound cases will be surprisingly reduced. When, however, suppuration follows in spite of this treatment drainage should be prompt and free, and attention should be given to the cultivation of granulation tissue so the wound may heal from the bottom in the shortest time possible. The fact that the wound is infected does not mean that the asepsis employed in the dressing of the wound should be anything but the most rigid. Even though suppuration is present it should not be forgotten that it is possible to introduce bacteria of other strains which are sometimes productive of the most disastrous results. For example a compound fracture may be infected with pyogenic bacteria and still be making good progress toward recovery; if some virulent infection, such as erysipelas or the gas bacillus, gains entrance to the wound the termination may be fatal within a short time.

The use of the so-called antiseptics within the wound are as useless and harmful here as in the initial treatment of the wound. The chief concern, after suppuration is established, is in the cultivation of granulation tissue so that the wound will heal from the bottom and cover the fragments. In order that this may be accomplished drainage should be free and fluids coming in contact with the granulation tissues should be isotonic, and the dressings should not adhere to and tear the granulation tissue when removed. Accordingly physiological sterile salt solution should be used in irrigating the wound, and balsam of Peru is one of the best materials to stimulate the granulation tissue and prevent it from adhering to the dressings. Infection in a compound fracture is decidedly detrimental to union between the fragments, but it does not necessarily mean that non-union will take place. Many cases are shown in the preceding pages in which infection was present and still perfect union took place. In some fractures there may be considerable destruction of tissue in the wound which renders the condition compound, and in such cases it is often advisable to do a plastic sliding operation so the wound may be closed even at the expense of leaving some adjoining region partially denuded.

In compound luxations the cleansing and trimming away of lacerated tissue involves the same principles as already described. If suppuration develops subsequently the joint should be aspirated and injected with Murphy's formalin-glycerine solution. More than one aspiration and injection may be necessary during the after-treatment, especially if the joint leaks through the wound following the first injection. The solution injected is two percent formalin in glycerine and should be made up the day before it is used. Enough of the fluid should be injected to gently distend the articulation. Murphy has demonstrated that this treatment of suppurative arthritis gives a much higher percentage of good functional results, and should always be tried out before open drainage of the joint is resorted to. When open drainage is established the result is almost invariably a stiff joint.

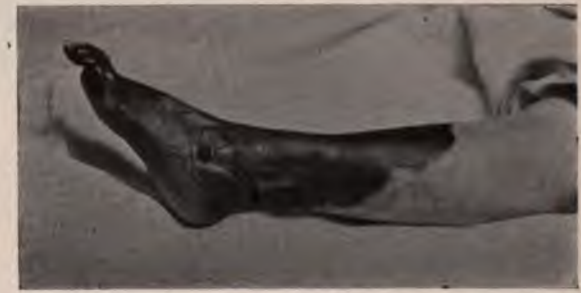


Fig. 860.—Gangrene following thrombosis.

The results in compound fractures and dislocations depend largely on the operative treatment immediately following the injury, and too much stress cannot be laid on the thorough washing of the wound and the trimming away of lacerated and devitalized tissue.

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